The Angle Orthodontist

January • 1960

Published Quarterly by
The Edward H. Angle Society of Orthodontia

Published Quarterly by the
EDWARD H. ANGLE SOCIETY OF ORTHODONTIA
Zuelke Building, Appleton, Wisconsin
Subscription Rates: $6.00 per year, Canada $6.25,
other foreign countries $6.50.

☆ ☆ ☆

Copyright, 1946, by the Edward H. Angle Society of Orthodontia

Second Class Postage paid at Appleton, Wisconsin

The Angle Orthodontist

January 1960

Volume 30, Number 1

Contents

1 • A CEPHALOMETRIC STUDY OF CRANIOFACIAL VARIATION IN ADULT TWINS
Sidney L. Horowitz, D.D.S., Richard H. Osborne, Ph.D. and Frances V. DeGeorge, M.A.

6 • A CROSS-SECTIONAL STUDY OF THE RELATIONSHIP OF FACIAL AREAS WITH SEVERAL BODY DIMENSIONS
Gerald J. Rose, D.D.S., M.S.D.

14 • FURTHER DEFINITION AND IMPLEMENTATION OF A CLINICAL IDEOLOGY
George L. Englert, D.D.S., M.S.D.

26 • A CEPHALOMETRIC APPRAISAL OF CLASS II AND CLASS III MALOCCLUSIONS
Prof. Dr. Giorgio Maj, Dr. Cesare Luzi, and Dr. Paolo Lucchese

35 • IDENTIFICATION OF LANDMARKS IN CEPHALOMETRIC RADIOGRAPHS
Peter K. Yen, D.M.D.

42 • PHYLOGENETIC FORCES OF GROWTH
George H. Prewitt, D.D.S., M.S.

DONALD H. GLEW

1900 - 1959

A Cephalometric Study Of Craniofacial Variation In Adult Twins

SIDNEY L. HOROWITZ, D.D.S., RICHARD H. OSBORNE, Ph.D. AND FRANCES V. DEGEORGE, M.A.

New York City

INTRODUCTION

The lack of available genetic data on human skeletal characteristics has had a limiting, if sometimes unrecognized, effect on progress toward the solution of some fundamental problems in anthropology and orthodontics. Although head form and facial proportions appear to be heritable, quantitative analysis of hereditary variability in cranial and facial dimensions in related individuals have been few. Consequently, attempts to establish morphological criteria for racial comparisons, or for orthodontic diagnostic purposes have been hampered by a need for more information relative to genetic variation in the face and skull.

The cephalometric roentgenographic method for obtaining skull measurements on the living has greatly facilitated research in growth and development of the head, and it is surprising that so few investigators have employed the technique in investigating hereditary variation. Wylie (1944) was the first to compare the craniofacial patterns of related individuals by means of the cephalogram, reporting on fifteen families of which thirteen had like-sexed twin pairs. Curtner (1953) reported on five families, three of which included twins. By superimposing tracings of various pairings in his study sample (mother-father, mother-daughter, father-daughter etc.) he determined "conformity" in various craniofacial outlines. Stein, Kelley, and Wood (1956) used the cephalometric x-ray in studying a large group of female college students, their siblings and parents. Four twin pairs were included in their investigation. The most recent reports are those of Noyes (1958), who presented cephalogram tracings of three generations of a family and a pair of twins as well, and Kraus, et al (1959), who studied six sets of triplets. Lundstrom's cephalometric study (1954, 1955) reported findings on the largest twin sample yet assembled, fifty pairs each of adolescent monozygotic and dizygotic twins.

In the present investigation the twin study method is employed in order to further explore genetic influences on variations in several craniofacial dimensions of a group of post-adolescent subjects in whom skull growth is essentially complete.

METHODS AND MATERIALS

A study which has been in progress for many years at the Columbia-Presbyterian Medical Center has drawn twin subjects, unselected as to sex and zygosity, from a variety of sources in New York City. The cephalographic study sample consisted of fifty-six pairs of like-sexed adult twins (thirty-five pairs monozygotic, twenty-one pairs dizygotic), having a median age of 24 years, with a range from 18-55 years. Diagnosis of zygosity was by the "proven dizygotic method," based upon blood group factors and reliable morphological characters. The method is discussed at length elsewhere. (Os-

School of Dental and Oral Surgery, and Institute for the Study of Human Variation, Columbia University, New York.

borne and DeGeorge)

Roentgenograms of the head in norma lateralis were obtained with each subject fixed in a Margolis cephalostat, employing a target mid-sagittal plane distance of sixty inches. Tracings of the headplates were made on tracolene paper, and second tracings of twenty of the headplates selected at random were used to determine measurement errors.

The following roentgenographic landmarks were used: nasion, sella turcica, Bolton point, articulare (Bjork), gonion, gnathion, point B, and the constructed points *x* and Ans′ (Fig. 1). Point *x* is determined by dropping a perpendicular from point B (Downs, 1948) to the mandibular plane and Ans′ is obtained by constructing a perpendicular from the anterior nasal spine to the line NGn.

Linear measurements only are reported in this study. Each dimension was measured to the nearest 0.5 mm and then the intrapair differences calculated. Comparisons were carried out between the average intrapair differences of monozygotic and dizygotic twins, expressed as variances. Fisher's F test was employed to test the significance of the observed differences.

Results

The intrapair variances obtained for each of the dimensions studied are presented in Table I. Three diameters, ramus height (Ar-Go), chin length, and the anterior concavity of the mandible (Meredith, 1957) showed sex differences upon comparison of the male-female intrapair differences of monozygotic twins and for that reason will be reported in a separate communication. No significant sex differences are apparent in the other dimensions studied. Therefore, the observations on male and female twins presented here have been combined for analysis.

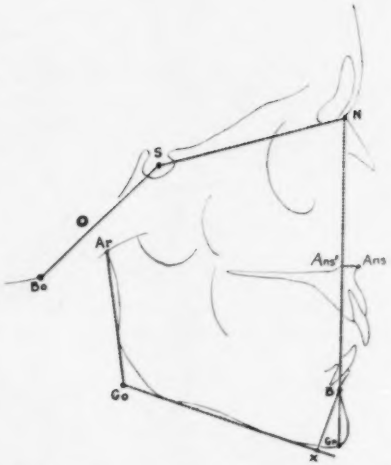

Fig. 1. Reference points used and linear dimensions recorded. (see text)

In dizygotic twins the variance found for the anterior cranial base (N-S) is about six times that calculated for monozygotic twin pairs, yielding an F ratio of 5.82 ($P < .001$). Thus, a strong hereditary component of variability is measured in this portion of the skull.

Although the dizygotic variance obtained for the posterior cranial base dimension (S-Bo) exceeds that of the monozygotic twin pairs, the difference is not statistically significant. Furthermore, as difficulty was encountered in accurately locating point Bo on some of the cephalograms, the measurement error variance (10.65) actually exceeds, though not significantly, the value obtained for monzygotic twin pairs. Bolton point has been similarly reported as an unreliable landmark by Bjork (1947), who considered it "inferior" to points such as Ar or N. It seems clear that further study of hereditary factors in the length of the posterior cranial base will require a more reliable posterior landmark than the Bolton point.

Mandibular body length was measur-

Table 1

MEAN INTRAPAIR DIFFERENCES IN LINEAR CRANIOFACIAL DIMENSIONS OF MONOZYGOTIC AND DIZYGOTIC TWIN PAIRS

Linear Measurement	N (Pairs)	Variance	F Ratio	P
N-S				
Monozygotic	35	1.650		
Dizygotic	21	9.607	5.82	<.001
meas. error	20	.363		
S-Bo				
Monozygotic	35	10.193		
Dizygotic	21	15.738	1.54	.10-.25
meas. error	20	10.65		
N-Gn				
Monozygotic	35	5.346		
Dizygotic	21	26.774	5.01	<.001
meas. error	20	.550		
N-Ans′				
Monozygotic	35	3.664		
Dizygotic	21	3.101	1.18	>.75
meas. error	20	.794		
Ans′-Gn				
Monozygotic	35	3.589		
Dizygotic	21	21.232	5.92	<.001
meas. error	20	.319		
Go-*x* (mandibular body length)				
Monozygotic	35	4.17		
Dizygotic	21	19.80	4.75	<.001
meas. error	20	.59		

ed from Go to *x*. Comparison of the variances of monozygotic and dizygotic twin pairs indicate a high component of genetic variability in this dimension ($F = 4.75$, $P < .001$).

Average intrapair differences between monozygotic and dizygotic twins in total face height (N-Gn) also demonstrate a relatively large hereditary component of variability ($F = 5.01$, $P < .001$). A similar, but less marked, difference was found by Lundstrom in his adolescent twin data.

When face height is analyzed in terms of the respective upper and lower components, however, it is apparent that these areas do not contribute equally to hereditary variation in total face height. The lower face (Ans′-Gn) shows high genetic variability, while the upper facial component demonstrates relatively little.

Discussion

The anterior cranial base region is of importance to orthodontists as it is an area common to both the cranial skeleton and facial skeleton (Scott, 1955). The relationship of the N-S dimension to facial prognathism has been discussed by Bjork (1947), and its correlation with "sturdiness" in body build proposed by Lindegaard (1953). Anteroposterior enlargement of the cartilaginous cranial base occurs in the fetal period by growth at the sphenoethmoid and spheno-occipital synchondroses and, while this area continues to grow postnatally, it does so slowly relative to the rapid growth

of the facial skeleton (Applebaum, 1953). Brodie (1941) and Ortiz and Brodie (1949) have analyzed postnatal growth in this region by means of serial cephalograms.

In his study of adolescent twin subjects, Lundstrom found twice as much intrapair N-S variation in dizygotic twins as in monozygotic pairs. This difference is much more apparent and confirmed with a high degree of significance in the present study of adult twin pairs in whom growth in this area is essentially complete. On the other hand, Kraus, Wise and Frei (1959), found "no greater similarity" in the diameter of N-S in monovular twins than in diovular twins, and question the utility of diameters and angles in recognizing the inheritance factor. Their method of superimposition of paired tracings in order to assess concordance in "total morphologic configuration" of individual bones appears itself to be open to question owing to its fundamentally subjective nature.

To the authors' knowledge no prior cephalometric data on hereditary variability in jaw length have been reported. The dimension utilized here (Go-*x*) measures what is essentially the tooth bearing (or "effective") length of the mandible which is of importance in orthodontic analysis. The chin portion of the jaw thus may be thought of as a "process" of the mandibular body. As mentioned above, the chin dimension, which is "bigger and juts more strongly forward in the masculine sex" (Hooton, 1947) will be discussed more fully in another paper.

Although little is known about the inheritance of individual variations in face form, anthropologists have felt that, apart from functional and age considerations, "inheritance does seem to manifest itself as a generally controlling factor" (Hooton). Longitudinal studies of the relation of nasal, or upper face height, and subnasal (lower) face height (Brodie, 1941) (Meredith, et al 1958) are in some disagreement as to the constancy of the relationship of these two components to one another during growth and development.

Comparison of the intrapair differences between monozygotic and dizygotic twins for upper and lower face height reveal a marked difference in the variability of these two components. Lower face height provides a significant measure of genetic variation, while upper face height does not. It is apparent that it is the lower facial component which is primarily responsible for the hereditary variation observed in total face height in these data. This finding appears to confirm the conclusion of Krogman and Sassouni (1957) that "the midfacial area seems more stable than the lower facial area." These variations have been measured in this study as *within-family* differences. Other studies which would permit a comparison of interfamily differences might demonstrate the existence of *between-family* genetic variation in either or both components of facial height.

One possible explanation for the unequal contributions of the upper and lower components to measurable genetic variation in face height may be found in the growth patterns of these two areas. Lower facial development, although it continues over an extended period of time, occurs at relatively few growth sites. The ultimate form and size of the upper facial region, however, is dependent upon numerous elements which interact with one another in a complex way. (Scott, 1958) Since there are fewer growth sites within the lower face than in the upper facial complex, this would mean, presumably, that fewer genetic factors are brought to bear on the growth pattern of the lower facial component. With fewer genetic factors operating, greater *within-family* seg-

regation would occur resulting in the relatively larger dizygotic intrapair difference in lower face height observed here.

Summary

1. The relative genetic variability of various dimensions of the craniofacial skeleton has been studied by means of roentgenographic cephalometric tracings of fifty-six pairs of like-sexed twins in whom skull growth was essentially complete.

2. Highly significant hereditary variations occur in anterior cranial base, mandibular body length, total face height, and lower face height ($P < .001$).

3. These data indicate that upper face height is the more stable element in the facial profile as it does not contribute greatly to the genetic variability of the face as a whole. Lower face height demonstrates a large degree of hereditary variability.

630 West
168th St.

References

Applebaum, E.: Integration of Anatomic and Cephalometric Studies of Growth of the Head. *Am. J. Ortho.* 39: 612, 1953.

Bjork, A.: The Face in Profile, Svensk Tandl. Tidskr. supp. 40, Lund, Berlingska Boktryckeriet, 1947.

Brodie, A. G.: On the Growth Pattern of the Human Head from the Third Month to the Eighth Year of Life. *Am. J. Anat.* 68: 209, 1941.

Curtner, R. M.: Predetermination of the Adult Face. *Am. J. Ortho.* 39: 201, 1953.

Downs, W. B.: Variations in Facial Relationships: Their Significance in Treatment and Prognosis. *Am. J. Ortho.* 34: 812, 1948.

Hooton, E.: *Up From the Ape,* MacMillan, New York, 1947.

Kraus, B., W. J. Wise and R. H. Frei: Heredity and the Craniofacial Complex. *Am. J. Ortho.* 45: 172, 1959.

Krogman, W. and V. Sassouni: A Syllabus in Roentgenographic Cephalometry. Univ. of Pennsylvania, 1957.

Lindegaard, B.: Variations in Human Body Build. *Acta Psychiat. et Neurolog.* Suppl. 86, 1953.

Lundstrom, A.: The Importance of Genetic and Non-genetic Factors in the Facial Skeleton Studied in 100 pairs of Twins. *Trans. Europ. Orthodontic Soc.* 92-107, 1954.

Lundstrom, A.: The Significance of Genetic and Non-genetic Factors in the Profile of the Facial Skeleton. *Am. J. Ortho.* 41: 910, 1955.

Meredith, H. V.: Change in Profile of the Osseous Chin During Childhood. *Am. J. Phys. Anthrop.* 15: 247, 1957.

Meredith, H. V., V. B. Knott and E. H. Hixon: Relation of the Nasal and Subnasal Components of Facial Height in Childhood. *Am. J. Ortho.* 44: 285, 1958.

Noyes, H. J.: A Review of the Genetic Influence on Malocclusion. *Am. J. Ortho.* 44: 81, 1958.

Ortiz, M. H. and Brodie, A. G.: On the Growth of the Human Head from Birth to the Third Month of Life. Anat. Rec. 103: 311, 1949.

Osborne, R. H. and F. V. DeGeorge: Genetic Basis of Morphological Variation. *Harvard Press,* Cambridge, Mass., 1959.

Scott, J. H.: The Variability of the Cranio-Facial Skeleton. *Trans. Europ. Orthodontic Soc.* p. 1-20, 1955.

————in Brash, J.: The Aetiology of Irregularity and Malocclusion of the Teeth. *The Dental Board of the United Kingdom,* 1956.

————The Growth of the Human Skull. The *J.* of the *Dental Assoc.* of *South Africa,* 13: 133, 1958.

Stein, K. F., T. J. Kelley and E. Wood: Influence of Heredity in the Etiology of Malocclusion *Am. J. Ortho.* 42: 125, 1956.

Wylie, W.: A Quantitative Method for Comparison of Cranial Facial Patterns in Different Individuals. *Am. J. Anat.* 74: 39, 1944.

A Cross-Sectional Study Of The Relationship Of Facial Areas With Several Body Dimensions

GERALD J. ROSE, D.D.S., M.S.D.
Washington, D.C.

INTRODUCTION

Over a period of years investigators have used a variety of methods of assessing and describing the variabilities of size, form, and relationship of the various parts of the face.

Anatomists and anthropologists have developed a series of schemata including important points on the dried skull as well as certain lines and planes. Anthropologists have also established a series of points and planes on the head of living.

The subject received a completely new treatment with the development of the cephalometer by Broadbent who made longitudinal studies of the growth of the head with the Bolton cephalometer. This remains a classic to investigations of this type. A few years after Broadbent presented his work, Brodie (1941) published his very important study on the growth pattern of the human head from the third month to the eighth year of life. His work indicates that the growth pattern of the human head is established at a very early age and shows little change. Broadbent superimposed the entire tracing of the head on his "registration point"; Brodie based his work on the measurement of the various parts of the skull after first laying them out as areas.

The tracing of the lateral cephalometric roentgenogram as used by Brodie is shown in Figure 1. In the present study, the areas measured were based on those of Brodie with several modifications of points and boundaries and are shown in Figure 2. This study is an attempt to extend and develop certain phases of the subject by the introduction of the measurement of areas in addition to the points and lines previously used.

Investigations with the cephalometric roentgenographic method have usually relied upon angular and linear measurements involving certain landmarks. The measurement of areas, however, offers a less limited and more inclusive approach.

Since areal measurement is not a very common technique, it may be well to give a brief statement of its use. The measurement of structures of the human body are commonly made in terms of one dimension, such as length, diameter or circumference, or in terms of three dimensions *i.e.*, volumes or approximately by weights. However, measurements in two dimensions *i.e.*, surfaces or areas are equally valid and are particularly useful in roentgenographic studies.

Quantitative studies of areal growth and dimensions of the human body are not new. The cutaneous or skin area was measured by Abernathy as early as 1795, and later determinations have been made by a number of other observers.

Putiloff (1886) measured the area of the serous membranes of the body, and gastric mucous membranes were studied by Dargien (1890) and by Scott (1929). The square inches of the cerebral cortex have been calculated by Wagner (1860), Aresu (1914),

Based on thesis submitted in partial fulfillment for the degree of M.S.D., University of Minnesota Graduate School.

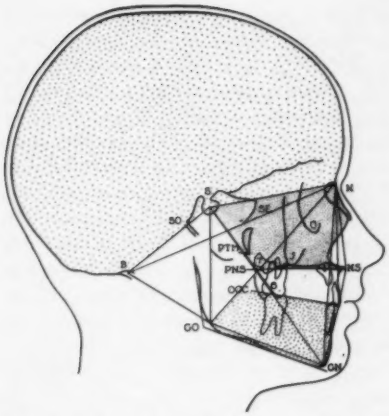

Fig. 1. A typical roentgenogram tracing of the head (after Brodie, 1941.) B, Bolton point; GO, gonion; N, nasion; NS, nasal spine; O, orbitale; OCC, occlusal plane; PNS, posterior nasal spine; PTM, pterygomaxillary fissure; S, sella turcica; SE, sphenoethmoidal junction; SO, spheno-occipital junction.

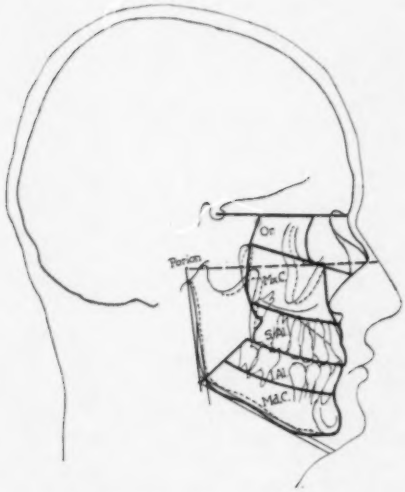

Fig. 2. Tracing of a right lateral roentgenogram of the head showing the facial areas as defined and used in this study. Heavy solid line shows boundaries of facial area. Or, orbitoethmoidal area; Mx.C, maxillary corpus area; S.Al., superior alveolar area; I.Al., inferior alveolar area; MaC., mandibular corpus area.

and Scammon and Hesdorffer (1936). The silhouette of the heart in the x-ray has been measured by Bamberg and Hermann (1919) and a number of other investigators. The area of the bones of the carpus as seen in the roentgenogram have been measured by Carter (1925, 1926) and others.

The general object of this study is to measure and compare the growths and sizes of the various facial areas with those of certain body measurements, and to determine the interrelationships of the facial areas. It also seemed desirable to justify or modify, as the case might be, the various existing schemata by which the face (in norma lateralis) is divided into areas of growth.

In this cross-sectional study of 125 standardized profile (cephalometric) roentgenograms and corresponding carpal films, the plan is to draw, by recognized and statistical methods, a picture of the relationships between each of the facial areas and stature, body weight, carpal rank, chronologic age, and the other facial areas.

This investigation is based on the parapuberal period when many changes are taking place in the body. It is also the period in which most of the permanent dentition is completed. The records and findings of the premenarchial females are separated from the postmenarchial females and, as will be pointed out, this division has been of great value in analyzing the material. No such division was made for the males for there is no effective way of making similar separation of the prepuberal and postpuberal cases.

The changes in growth and development in this parapuberal period are often very different from those of other divisions of the life cycle, preceding and following it. This was clearly pointed out by Muhlmann (1900, 1910) Hall (1904), Minot (1908), Scammon (1920, 1930), Davenport (1930), and

other observers, and has recently been demonstrated in detail by Shuttleworth (1938). Like the period of infancy and early childhood, the parapuberal period is one of rapid general growth. But otherwise, the two intervals are often very different. The central nervous system and the organs of special senses grow rapidly in the infant and young child. They are practically stationary in the parapuberal period. The organs of reproduction grow very little during the first six or seven years after birth; they increase over tenfold in the parapuberal years. The lymphoid structures and organs grow rapidly during the early part of the first decade; they are actually declining in size during adolescence. Merkel (1882) in an interesting paper on skull growth described a very different set of changes in the skull in the third epoch (about ten to about twenty years) from those of the first epoch (birth to about seven years) or in the second (about seven to about ten years). The paranasal sinuses (except for the ethmoidal cells) grow comparatively little in the six years following birth but increase rapidly in the parapuberal years (Maresh, 1940).

As mentioned above, one object of this study was to investigate the relation between the development of the facial areas and the status of carpal development.

The carpal bones have long been thought of as a criterion for determining skeletal ("anatomic", "physiologic") age. They have been used for determining the amount of calcification, and thus the degree of maturity of the bones of the body as far back as 1848 by Quain.

A given series of carpal plates can be arranged by three methods: (1) by inspection, (2) according to individual bone-area measurements or the sum of such bone-area measurements, and (3) by seriation.

With the ranking or seriation method, a series of roentgenograms, preferably a large series, is taken with the same magnification and under standardized conditions. These are then arranged before a light source and sorted into an order indicated by the degree of development each patient exhibits. Since it is possible to shift the plates at will, a very exact graduation can be obtained. This ranking is commonly done independently by two or more observers and is tested for consistency by rank correlations of the ratings turned in by each observer. Most of the modern series of carpal ranks, such as those of Flory (1936) and Todd (1937) were made by this method and its use is regarded as a standard research practice.

Material and Method

This study was based upon individuals of the parapuberal period, defined as extending from nine to eighteen years. These age limits may seem rather extreme, but modern studies by Shuttleworth (1937, 1938), Richey (1937) and others show that, while the puberal changes in bodily growth commonly reach their maxima in the thirteenth year for American girls and in the fourteenth and fifteenth year for American boys, they frequently begin in the ninth and tenth year and are still evident in a reduced degree in the eighteenth year.

The individuals were taken at random, except for age, from patients of the pay clinic of the University of Minnesota Dental School. No special study was made of their origins, but previous studies on individuals of this age group in the University hospitals and clinics indicate that they are practically all American-born, mainly of the second and third generation, of diverse nationalities as regards family origins, but almost all of Northern European stock. In all, some 225 individuals were meas-

ured anthropometrically*, given dental examinations and x-rayed for lateral oriented head plates and right wrist roentgenograms. From this collection, 125 individuals were taken. These consisted of three groups, 50 males, 30 premenarchial females, and 25 postmenarchial females. The separation of these cases from the original mass of material was done by strict random sampling except in one or two instances where the cases were rejected because of indistinct x-ray plates and were replaced by cases taken by chance from the general supply.

A tracing of each head x-ray was made on 0.003 plastic matte tracing film (Eastman) for measuring purposes. The boundaries were marked off according to a plan to be described later. Each tracing then consisted of five separate areas, each quite irregular in shape, which were measured directly in square inches with an instrument called a planimeter.

It is desirable to compare, insofar as possible, the great bodily measures of the present group of children with those of a larger sample of the local population as a whole, with a view of determining if the present small group is a moderately representative one. This is possible by the use of the O'Brien, Girschick and Hunt tables.

When this comparison is made, it is found that the stature is about the same (within one inch) for each of the three groups and the corresponding O'Brien, Girschick and Hunt standards. The premenarchial and postmenarchial females are a little heavier (four to five pounds) than these standards and the weight of the males is almost the same. The coefficients of variability in stature and body weight of the three groups are of the same order of magnitude as those found by O'Brien, Girschick and Hunt. It is probably safe to assume that insofar as stature and weight are concerned, the present sample is fairly representative of the population from which it was drawn.

*Height (inches) without shoes, weight (lbs.) normal indoor clothing, age (mos.), bideltoid and biachromial distances. The latter mentioned distances were later discarded because the height measure proved so reliable.

The Facial Areas

The problem of establishing boundaries for the several facial areas is not only one of growth demarcation but one of practicability. The area limitations must consist of points and outlines that have easily visible shadows on the roentgenogram.

The facial boundaries of the present study enclosed those areas where growth demarcation seemed reasonable and consisted of points and outlines easily identifiable on the x-rays.

The facial areas were:

1. Orbitoethmoid (Or.)
2. Total maxillary — a combination of maxillary corpus (Mx.C.) and superior alveolar (S.Al)
3. Mandibular areas — a combination of inferior alveolar (I.Al) and mandibular corpus (Ma.C.)

Specifically, the basic boundaries were drawn to encompass the following areas. Some of the finer details and the reasoning behind them have been omitted for the sake of clarity.

1. Orbitoethmoid (Or.) designed to include the orbit and more specifically to exclude it from the growing facial area beneath it:
   (a) nasion to center sella turcica
   (b) sphenoethmoidal junction to superior anterior angle of pterygomaxillary fissure.

(c) most forward boundary of orbit as seen on roentgenogram

(d) to inferior border orbit.

2. Total maxillary area:

(a) anterior border pterygomaxillary fissure around the maxillary tuberosity to encompass any crowns

(b) irregular line drawn along anterior margin facial skeleton including tip of central incisor

(c) smooth curve (drawn with aid of appropriate French curve) from incisal tip of central incisor through first molar cusps.

3. Mandibular areas:

(a) straight line from gonial angle to intersection of occlusal curve

(b) tracing of remainder of mandible.

After tracing, each area was measured with a planimeter. This device automatically computes the area (in square inches) of an irregularly-shaped, flat surface with great accuracy. Tests made by retracing several of the cephalometric x-rays and again measuring them showed no appreciable difference between tracings.

The comparisons were made by rank correlation with each area's dimensions being compared with that of each of the other areas.

The carpal assessment was accomplished by the serial ranking of each individual's wrist x-rays to determine the relative calcification of the respective x-ray in the group.

Findings

1. Chronological age proved an ineffectual guide to the growth and development of facial areas in the parapuberal period.

2. Measures of carpal rank also proved an ineffective guide to facial development.

3. Stature and body weight proved the best indicators of facial development found in this study. Both show distinct concomitance with facial growth during this period.

4. A particularly close concomitance exists between the total maxillary area and mandibular areas in the three groupings. (Premenarchial female, postmenarchial female, male.)

5. Orbitoethmoidal area shows little if any relation to other facial areas or to stature, body weight or age increase.

6. There is distinct difference in size of facial areas in favor of males when compared with premenarchial females.

7. Postmenarchial status seems to cause a slowing of the rate of increase of size of the total maxillary and mandibular areas; critical ratios indicate that this is not entirely due to increased chronological age.

8. Relative rates show that all facial areas are undergoing a reduction in percentage increase in the postmenarchial period.

9. The orbitoethmoidal area grows quite differently from the total maxillary and mandibular areas and its style of growth may be said to approach the neural type. Its inclusion as a typical facial area is most questionable.

10. Fourteen empirical formulas were developed by expressing the growth of facial areas in relation to other measurements in each of the fourteen instances where the respective correlates showed distinctly significant coefficients of correlations. This is shown in Table 1 and Figure 3.

Discussion

It may be pointed out at the beginning of this discussion that all the findings under consideration are concerned only with the parapuberal

Table 1

Empirical Formulae for Prediction of Average Values of Facial Areas from Stature, Body Weight and Other Facial Areas

(Constants of Formulae and Mean Weighted Errors, or Residuals, for Averages.)

General Formula: $A = aB \pm b$

For Prediction of "A" From "B"		Constants of Formula		Mean Weighted Errors of Averages	
A	B	a	b	sq. in. 100	per cent
MALES					
Total maxillary area	Stature	6.07	— 0.33	4.6	1.3
Total maxillary area	Body weight	0.97	+236	8.3	2.2
Mandibular areas	Stature	7.45	— 81.3	5.2	1.4
Mandibular areas	Body weight	1.02	+267.5	3.3	1.0
Mandibular areas	Total maxillary area	0.708	+ 77.8	1.6	0.5
PREMENARCHIAL FEMALES					
Total maxillary area	Stature	6.04	— 16	0.9	0.3
Total maxillary area	Body weight	1.064	+241.2	2.3	0.6
Mandibular areas	Stature	4.54	+ 55.6	3.1	0.9
Mandibular areas	Total maxillary area	0.677	+ 94.6	4.3	1.7
POSTMENARCHIAL FEMALES					
Total maxillary area	Stature	5.76	— 13.8	5.4	1.2
Total maxillary area	Body weight	0.799	+268	3.4	0.8
Mandibular areas	Stature	6.34	— 61.9	3.8	1.0
Mandibular areas	Body weight	1.43	+172.5	1.4	0.3
Mandibular areas	Total maxillary area	0.458	+160.1	8.9	2.6

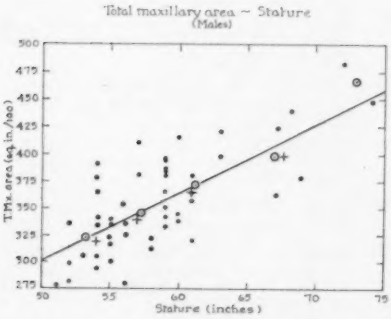

Fig 3. A typical field graph of the relation of total maxillary area to stature for males. The dots represent individual cases and the circled dots represent means. Crosses show medians. The solid line, a representation of the central trend, was drawn to the empirical formula. Total maxillary area (sq.in. /100) = 6:07 Stature (in.) — 0.33.

period. It is interesting to note that chronological age and carpal ranking did not prove to be as reliable a guide to facial development as stature and body weight. From this we might find an indication that general body growth — usually demonstrated by stature and weight — does bear some relation to facial growth.

It was expected that the orbital area, which from previous investigations had been found to follow the neural type of growth, would show little relationship to facial or general body growth.

The postmenarchial status caused a decrease of the relative rate of facial area growth when compared with the premenarchial group. It would have

been advantageous to have been able to divide the data for males similarly.

The development of empirical formulae as listed are of value in that they exhibit some order to a series of plottings on a field graph.

As a whole, the first or "a" constants of the formulas which are multiplying factors and represent absolute rates of increase are remarkably consistent. They are of the same order of magnitude for given correlates in all three sets of data (male, premenarchial and postmenarchial females).

The mean weighted relative or percentage residuals range from 0.3 to 2.6 per cent, being above 2 percent in only two instances. They show no particular consistency but they indicate a high degree of correspondence between observed and calculated means. Most empirical formulae based upon data on human structures show mean weighted relative residuals ranging between 5 and 10 per cent.

The author wishes to acknowledge the assistance given by Drs. S. R. Steadman and R. E. Scammon in this study.

1726 Eye Street, N.W.

BIBLIOGRAPHY

1. Abernethy, J.: An Essay on the Nature of the Matter Perspired and Absorbed from the Skin. *Surgical and Physiological Essays*, Pt. II, 107-165. London, 1795.
2. Aresu, M.: La superficie cerebrale nell' uomo. *Arch. Ital. di Anat, e di Embriol.*, 12:380-433, 1914.
3. Bamberg, K. and Hermann, P.: Die Herzgrosse in Sauglungsalter auf Grund von Rontgenferaufnahmen. Ztschr. f. Kinderheilk., (orig.), 20:195-211. 1919.
4. Bayley, N.: Skeletal Maturing in Adolescence as a Basis for Determining Percentage of Completed Growth. *Child Development*, 14:1-45, 1943.
5. Boyd, E.: The Growth of the Surface Area of the Human Body. 145 pp. Minneapolis: *Univ. of Minnesota Press*, 1935.
6. Broadbent, B. H.: A New X-ray Technique and its Application to Orthodontia. *Angle Ortho.* 1:45-60, 1931.
7. Brodie, A. G.: On the Growth Pattern of the Human Head from the Third Month to the Eighth year of Life. *Am. J. Anat.* 74:39-60, 1941.
8. Carter, T. M.: Technique and Devices Used in Radiographic Study of the Wrist Bones of Children. *Jour. Ed. Psychol.*, 17:237-247, 1926.
9. Dargien, P.: Surface et Volume Comparés de l'estomac et du Duodénum. *Biobl. Anat.*, 7:207-216, 1899.
10. Davenport, C. B.: Adolescent Spurt in Growth. In: Memorial Volume in Honor of Sixtieth Birthday of Vladislaw Ruzicka, Prague, 1930.
11. Engel, M. B.: Planimetric Analysis in Cephalometric Roentgenology. *Jour. Dental Res.*, 27:758, 1948.
12. Flory, C. D.: Osseous Development in the Hand as an Index of Skeletal Development. Monogr. Soc. for Res. in *Child Development*, 1:no.31, 1936.
13. Hall, G. S.: Adolescence. New York: *D. Appleton and Co.* 1904.
14. Maresh, M. M.: Paranasal Sinuses from Birth to Late Adolescence. *Amer. Jour. Dis. Child.*, 60:55-78. 1940.
15. Minot, C. S.: The Problem of Age, Growth and Death. New York: *G. P. Putnam and Sons.* 1907.
16. Muhlmann, M.: Ueber die Ursache des Alters. xii 195 pp. Wurzburg: H. Sturtz., 1900.
17. ——— Das Altern und der Physiologische Tod. Ergänzungen zur Physikelischen Wachstumslehre. Samul. anat. u. physiol. Vortr. u. Aufa., 1:453-496, 1910.
18. O'Brien, R., Girshick, M. A. and Hunt E. P.: Body Measurements of American Boys and Girls for Garment and Pattern Construction. U.S. Dept. Agriculture, Miscl. Publ. No. 366, U.S. Government Printing Office. 1941.
19. Putiloff, P. V.: Materials for the Study of the Laws of Growth of the Human Body in Relation to the Surface Areas of Different Systems in the Infant and Adult Organism. (Russian) Omsk, Siberia, 1886.
20. Quain, J.: (Quain, R. and Sharpey, W. Eds.) Human Anatomy. London, 1848.
21. Scammon, R. E.: Some General Characters of the Postnatal Growth of the Various Organs in Man. *Anat. Rec.*, 18:256-257, 1920.
22. Scammon, R. E. and Adair, F. L.: The Geometric Relationships of the Frontal Fontanelle in Infancy. *Anat. Rec.*, 46:349-363, 1930.
23. Scammon, R. E. and Hesdorffer, M. B.: Growth of the Human Nervous System. *Proc. Soc. Exp. Biol. and Med.*, 34:273-277,1936.

24. Scammon, R. E. and Scott, G. H.: The Technique of Determining Irregular Areas in Morphological Studies. *Anat. Rec.*, 35:289-277, 1927.

25. Shuttleworth, F. K.: Sexual Maturation and Physical Growth of Girls. Monog. Soc. Res. in *Child Develop.*, 2:No.5, 1937.

26. Shuttleworth, F. K.: Sexual Maturation and Skeletal Growth in Girls Age Six to Nineteen. Monog. Soc. Rec. in *Child Develop.*, 3:No.5, 1938.

27. Todd, T. W.: Atlas of Skeletal Maturation. St. Louis: *C. V. Mosby Co.*, 1937.

28. Wagner, M.: Massbestimmung der Oberflache der grossen Gehirus. *Cassel*, 1864.

29. Wylie, W.L.: The Assessment of Anteroposterior Dysplasia. *Angle Ortho.* 17:97-109, 1947.

Further Definition And Implementation Of A Clinical Ideology

GEORGE L. ENGLERT, D.D.S., M.S.D.
Danville, Illinois

When it was suggested that the procedures followed in my office would be of important interest to this group, I accepted the assignment because I have always felt an obligation to further explain my ideologies of treatment of malocclusion and the results obtained. These results have been shown in plaster clinics during the seminars of this Foundation and, from time to time, at other orthodontic meetings. In speaking of these results, there is no claim of individuality except that I am primarily interested in the ultimate stability of the corrected malocclusion after all appliance therapy, including retention, has been discarded. This objective, of course, is the goal of all good orthodontics. Together with the health and welfare of the teeth and supporting tissues, this final stability becomes the greatest responsibility of the orthodontist and the basis for all rational procedures in practice.

A serious doubt that I have always had concerns the advisability of utilizing techniques which set up dangerous reciprocal forces, particularly if patient cooperation is required in order to neutralize the undesirable effects of appliance therapy. As we all know, the reciprocal action of appliance techniques is the biggest bugaboo in orthodontics. It is a well known law in physics that every action has an equal and opposite reaction. When applied to orthodontic therapy, this means that every desirable appliance action has an equal and opposite undesirable reaction. In unskillful management of cases or a lapse in necessary patient cooperation, the undesirable effects will neutralize the desirable effects to the extent that one pattern of malocclusion is exchanged for a new pattern of malocclusion. To a lesser degree in case mismanagement or lack of patient cooperation, what appears to be an acceptable end result will prove unstable because of a degree of displacement permanently of reciprocal units involved for anchorage purposes. In this respect I am thinking particularly of cases where anchorage units have been displaced farther forward than is permissible for the positioning of the entire denture in balance on apical base.

In every case the degree of potential permanent displacement of reciprocal units is related to the degree of the anchorage problem and to the severity of reciprocal appliance action. While anchorage preparation may effectively minimize such effects, I consider it wiser to avoid or, at least, minimize, such dangerous reciprocal action wherever possible.

Any discussion of appliance therapy must begin with band placement and construction. Band placement and construction is the absolute foundation of all appliance therapy. A rational, regular, and exact positioning of all bands is absolutely essential for unobstructed, orderly functioning of the appliances. A smooth working appliance is essential for success in treatment. I, for one, never want to offset an archwire in any degree to compensate for lack of uniformity or an error in band positioning. I will always reposition or even

Read before the Charles Tweed Foundation, Palm Springs, California, 1958.

remake a band in order to avoid a bend in an archwire.

Any discussion of angulation of brackets or of second order bends or tip backs, as we know them in archwires, is meaningless without consideration of band alignment on individual teeth. I establish a uniform level of all brackets on all teeth by gauging from the occlusal or incisal edge of the bracket to the tip of the highest buccal cusp or incisal edge. For a gauge I use a Number 2 round Black's amalgam plugger. This plugger is employed in a dual capacity — as a pusher or burnisher, and as a gauge in the initial fitting of every band. For all band strips with preassembled brackets, I gauge from the ear of the bracket to the most prominent cusp or the incisal edge of the tooth. For cuspids I use contoured cuspid blanks without brackets and I gauge from the incisal edge of the band to the tip of the cusp and, when the bracket is installed later, it is assembled with the edge of the bracket even with the incisal edge of the band, thus establishing a uniform level of the bracket with the other brackets preassembled on strips.

For molars I use .180 band material or contoured blanks and establish the level of the band on the tooth at the distal marginal ridge of the molar tooth. Molar tubes or brackets are then installed midway between the occlusal and gingival borders of the band. I have found in practice that this method establishes a uniform level of the molar bracket or sheath with the brackets preassembled on the strips as used on bicuspids and anteriors as well as on first molars, and with cuspid brackets installed as previously explained. I should add that the cuspid technique of positioning the bracket at the incisal edge of the band positions the band gingivally to a maximum degree for retention on these conical and tapering teeth and, at the same time, insures the leveling off of the tips of the cuspids with those of the other teeth.

Alignment of the bands upon the teeth at the given level is the next item of discussion. As mentioned, the degree of angulation of brackets, or of second order bends, or tip backs in archwires is meaningless unless based upon standardized alignment of bands upon the teeth with regard to their long axes. It will be noted in studies on tooth anatomy that the vertical dimension or height of the crowns of teeth is greater at the mesial surface than at the distal surface. Thus, a line positioned at right angles to the long axis of the tooth and at a level with the distal marginal ridge of the crown of the tooth will usually pass gingivally to the mesial marginal ridge. This would also be true of a line drawn around the circumference of the tooth at the level of the distal marginal ridge. Because of this and because of the nature of the contours of the crowns of teeth, it has been my clinical observation that, when the ends of a band strip are brought together in perfect alignment with each other, no offset permitted, the mesial side of the band will pass below the mesial marginal ridge when the distal side of the same band is even with the distal marginal ridge.

This alignment of a band on a tooth with a parallel bracket will not only insure maximum uprighting of the tooth on its long axis, but will also provide a degree of distal tipping with a straight archwire dependent upon the individual tooth anatomy or difference in mesial and distal vertical heights of the crown of the tooth. Since, in this respect, there tends to be a natural uniformity of teeth in the same mouth, it follows that a straight archwire will establish a natural degree of uprighting or distal tipping of all teeth in the mouth. Please bear in mind that the degree of this action will vary accord-

ing to the individualities of dental anatomy.

Gauging the level of the bands upon the teeth may vary also in extreme cases. For long teeth and long cusps, I use a Number 3 Black's plugger in place of a Number 2 for my gauge. In the case of the incisor teeth I always align the edge of the bands with the incisal edge. This will require the offsetting of the ends of the bands on the lingual in some cases.

The natural degree of uprighting or distal tipping with a straight archwire upon cuspids and posterior units by band alignment, according to the method described, is usually all that is employed.

For the rotation of all bicuspid teeth and lower anteriors, I center one staple on the lingual surface of the band. This is preferred for the simplicity of rotation in either direction provided by one such staple and because it insures the maximum leverage for rotation stress or tension. Also, this single staple principle makes most effective use of the compression of a coil spring between the bracket and the rotating ligature tie in maintaining tension upon the rotation ligature.

In line with my policy of avoiding unnecessary reflex action in appliance therapy, I favor a method of rotation that requires no flexing or reflex action of the archwire. This is a method learned from our Cuban members who first demonstrated it at a seminar in Tucson. The method not only avoids unnecessary movement in the archwire but also provides most effective and rapid rotations of teeth when used in connection with the lingual staple.

A section of open wound coil spring .010 by .030 and usually three sixteenths of an inch in length is installed on the archwire, round or rectangular, and compressed against the bracket by tying the lingual staple. The length of the spring section should vary, of course, in relation to the size of the teeth. It should exceed the distance between the bracket and the proximal side of the band and should not exceed the distance to the brackets of adjoining teeth when rotations have been completed. If the length of the spring section is precisely determined according to the distance between brackets, the rotating tie may be unnecessary on the tooth to be rotated, but the rotation of the adjoining tooth must be stabilized by a counter rotational tie. While some may not approve, I do not consider the additional interproximal space required for the passage of a rotating ligature between teeth as a serious obstacle. Such a space immediately disappears following discontinuance of the ligature.

From the beginning and throughout treatment, all lower archwires are made flat from anterior to posterior. All upper archwires are provided with compensating curves. Flattening and leveling the lower arch thus from the beginning adds a degree of uprighting to that already provided by the alignment of bands as previously described. This is true, I believe, because the natural state of the lower teeth is in the Curve of Spee and any leveling and uprighting of the posterior teeth in flattening this curve will, in effect, constitute tip back action. Of course, the simultaneous leveling or depression of the lower anteriors will open the bite according to the degree desired.

In the upper arch the compensating curve of the archwire incorporates a similar effect upon the upper denture. Since the normal axial inclinations of upper molars in the compensating curve are toward the distal, the curvature of the upper arch in compensating curve formation automatically provides a degree of tip back upon these teeth. At the same time this curvature will tend to elongate second bicuspid and first bicuspid units and depress up-

per anteriors with a resulting open bite effect. Furthermore, the effect of the compensating curve on the anterior section of a rectangular archwire automatically provides a degree of lingual root torque or labial crown torque according to the degree of the curvature. This is all the torquing action that I usually employ on these teeth. The torquing effect in the anterior section of a lower flat rectangular arch likewise establishes a degree of labial crown torque and lingual root torque on the incisors. This torquing action tends to resist excessive lingual inclination of the teeth.

In selection of the types of brackets used, the system of rotation is an important factor. The use of coil spring sections compressed between the bracket and a rotation tie, as mentioned previously, works best with a single solid type of bracket because of the space required for the coil spring section on the archwire. For this reason, I use the single, regular type brackets on all lower incisors, on upper lateral incisors and on all bicuspids. The large single posterior type bracket is used on upper central incisors, upper and lower cuspids, and on upper and lower first molars when second molars are to be banded and engaged. Rotation staples are provided on the labial surfaces or, on buccal surfaces in the case of molars, for these units, except the lower cuspids which carry a single rotational staple on the lingual.

Furthermore, I do not approve of unnecessary flexing of archwires in order to accomplish rotations. The reciprocal wave-like actions set up in the archwire therefrom are very disturbing to the adjacent teeth and will even produce expansion effects in an archwire intended to be passive in this respect. Physiological disorganization in the bone around the roots of teeth so affected, I am sure, reduces the effectiveness of these units for anchorage purposes. The movement of teeth in undesired directions in order to accomplish a given type of movement in other teeth is always to be avoided, if possible.

Another consideration that applies in the management of all types of cases is the number of teeth to be banded and engaged. In the management of all types of extraction cases, I have found it imperative to band and engage the second molars. This is necessary in order to obtain the proper leverage of the archwires in leveling the lower arch and producing the necessary compensating curve in the upper arch. If second molars are not banded and engaged in extraction cases, the posterior segments of the archwires are so foreshortened that they provide little leverage action for vertical height adjustment in either arch. Unless a minimum of three units distal to the cuspids is engaged on each side, there will be little depressing action on the anteriors above or below, and second molars are likely to extrude occlusally above and beyond the banded teeth.

When second molars are not erupted and available for banding at beginning of treatment and it is planned to engage them in the course of the treatment plan, I use the wide posterior brackets on the first molars with a mesial staple to be used as a counter rotation tie when any mesial traction is to be applied to these teeth before the second molars have been engaged.

There are exceptions in banding second molars, of course, in cases where little or no leveling or bite opening is required on the anterior units of extraction cases and when the anchorage situation permits. In non-extraction cases, banding of second molars may not be necessary except in critical anchorage situations and in severe closed bites.

With regard to central and lateral

incisors, these teeth are usually not banded at the beginning of treatment where any crowding exists. Exceptions to this are in extreme closed bite situations such as Class II, Division 2 cases when the resistance of incisor teeth is utilized to assist in the uprighting or leveling action of archwires in the beginning phases of treatment, and to retract the upper incisors to the maximum practical extent in order to get them out of danger and to facilitate normal tongue and lip action.

As a cardinal principle in my management of cases, all rotations are taken out coincident with leveling treatment. This is considered essential for free and smooth working of appliances, the elimination of occlusal interferences, and for minimizing retention after treatment.

The time for extraction of teeth is something that I vary according to the circumstances of the case. In order to prevent avoidable mesial migration of anchorage units during the initial leveling and uprighting stages for these teeth, I very often postpone extraction of the selected units until this phase of treatment is over. This is done so that pressure on the contacts between the teeth will be maintained as a block to the undesirable forward movement of posterior units. Teeth to be extracted may or may not be banded during the period depending upon whether I wish to use them in any way to assist in appliance action.

In Class I cases I do not extract lower units until the upper cuspids are occluded well distal to the lower cuspids. This is done to avoid functional occlusal interferences to the upper cuspids in their distal movement and to assist them in every way possible. Extraction of the selected lower units follows as soon as practicable in this respect.

In Class II, Division 1 cases all extractions are performed simultaneously except when an attempt is made to reduce the Class II relation first. When this has been accomplished, the procedures as in Class I cases apply.

In Class III cases and anterior cross bites the extraction of the lower units is performed first. The extraction of upper units is usually not performed until the lower anteriors are functioning in their normal incisor relationship to the uppers; however, this procedure is varied in cases where one or more upper central or lateral incisors are lingual to adjoining teeth to the extent that they would interfere with this normal incisor relationship with the lowers. Then all selected units would be extracted simultaneously so that upper cuspids may be moved sufficiently to permit normal alignment of the upper centrals and laterals.

In Class II, Division 2 malocclusions I prefer not to extract at all. I have found in these cases that the apical base is usually adequate for the complete dentition and the skeletal pattern is regular. I think the etiology of this type of malocclusion is musculature with mandibular displacement distally. I believe that extraction in these cases tends to precipitate relapse. I have treated cases in this class successfully after mutilation by the loss of first molars and, in one case of full complement of teeth, I have extracted second bicuspids. So there are exceptions. I did, however, reduce the Class II relation before I extracted in the one case. In any case of this type I prefer to do that before extraction is considered.

The next factors to be discussed in the management of all types of cases are the techniques used in the retractions of cuspids and other anterior teeth. The methods used follow the aforementioned principles of facilitating, stimulating and guiding growth. Also involved are the principles of avoiding unnecessary reciprocal actions,

particularly extreme degrees of such action and the avoidance of a requirement for patient cooperation whereever possible. The technique begins with removal of the obstacles or impediments to balanced and harmonious growth and development in the form of the units to be extracted. Those of us who have had the patience and have not been too hasty in our actions have learned that cuspids upright themselves under the influence of the labial musculature of the mouth when such movement is unobstructed by other teeth, occlusal interference, or appliances. This is nature following her own instincts and helping herself when given the opportunity. There are exceptions of extremely malposed teeth where this phenomenon may be too slow and require assistance.

After these cuspids have attained a vertical position or a relatively normal axial alignment, further distal movement, bodily in scope, will require stimulation and guidance. For this further stimulation and guidance, I endeavor to continue to employ the influences of the labial musculature plus an appliance action which has its primary reciprocal forces dissipated in a lateral direction rather than anteriorly against posterior anchorage units.

The method is applied to both upper and lower dentures and is as follows: When the leveling and rotation phases have been completed to the extent that bracket engagement for all teeth concerned is free and easy on an .020 round arch, the distal movement of cuspids is begun. A round .020 wire is fashioned into the form desired, without tiebacks or stops of any kind, but long enough to extend three sixteenths of an inch beyond the distal margin of the molar sheaths, level in the case of the lower arch and with compensating curve in the case of an upper arch. Several inches of open wound coil spring .010 by .030 are slipped over a corresponding length of .030 round wire. The entire length of spring is then compressed to the maximum extent and released. This will tend to shorten the length of spring as a whole and will stabilize the length of this coil. If this is not done, improper handling or tinkering by the patient may alter the length of the coil spring after its installation and shorten it in such a way that it becomes inactive.

After this conditioning, a length of the spring one quarter inch longer than the distance around the arch from cuspid bracket to cuspid bracket is installed on the archwire and the wire tied in. All bracket ties are made easy enough to permit free movement of the archwire anteriorly and posteriorly in the channels. On the cuspid brackets, the tied ends of the ligature bracket tie are placed at the distal of the brackets. A counter rotational tie is usually made at the distal on the cuspids and a mesial counter rotation ligature is attached to all second bicuspids. This stabilization of rotation is necessary. Otherwise, the cuspids to be moved distally may rotate distally and second bicuspids, though straight, may tend to rotate mesially. If this rotation were permitted on the second bicuspids, any possible anchorage value of these teeth would be reduced. After passing through the last molar sheaths, the distal ends of the archwire for one sixteenth of an inch are turned lingually or palatally forty-five degrees or more. Since the wire has been allowed to extend three sixteenths of an inch beyond the distal end of the molar sheaths, this provides one eighth of an inch of free travel forward of the entire archwire.

Thus, this archwire may be described as a floating arch, because it may float anteriorly a distance of one eighth of an inch from contact with central incisors without creating any drag on the anchorage units other than that

inherent in the friction within the channels of the brackets.

This archwire and anterior coil section exert a distal stimulation against the cuspids in the following manner. The action is provided primarily through one quarter inch over-extension of the anterior section of coil spring when compared with the circumference of the arch between the cuspid brackets. Whether the archwire is positioned distally to the maximum extent, that is, with the anterior section up against the central incisors or whether it has floated anteriorly to a comparative degree, there is always the influence of the labial musculature bearing posteriorly across the entire anterior segment of the arch and spring. This influence is particularly active when the wire has floated forward to the maximum extent or degree extending the appliance against the labial musculature. This restraint, in itself, is sufficient to move cuspids distally when unopposed or unobstructed by other teeth or appliances.

In addition to this posterior pressure from the lip, there is additional pressure stimulation from the compressed anterior section of coil spring when the archwire is positioned distally within one eighth inch of the central incisors. The direction of force is directed distally from the ends of the coil spring section against either cuspid bracket while reciprocal forces in the opposite direction are dissipated around the archwire in a direction laterally against the wire until completely dissipated in a lateral direction right and left at the mid-line. This exemplifies a principle of physics as follows: when two equal forces, originating at different points, meet at an angle, their combined reciprocal action or direction of force will be along a line or axis bisecting the angle at which they meet.

Thus, assuming that the curvature of the anterior segment of the archwire is symmetrical, the reciprocal action of a cuspid to cuspid coil would be along two lines or axis on either side, through points midway between the median line and the ends of the coil section on the archwire, and a point at the median line of the arch or palate directly in line with both ends of the coil section. In our appliance action, therefore, the reciprocal action of the distal force against the cuspid brackets at the ends of the coil section, which tends to float the entire arch anteriorly, is much less than the effective action against the cuspids in a distal direction.

In addition to this reduction of reciprocal forces, the freedom of the arch to float through the channels of the brackets minimizes any drag on the anchorage units until this effect is nil.

The activation of this appliance is checked at regular intervals throughout this step in treatment. Whenever the circumference around the arch from cuspid to cuspid bracket is within one eighth of an inch or less than the length of the coil in action, a new archwire and a longer coil section are installed as in the beginning, or a new longer section of anterior coil may be slipped over the end of the old wire by freeing only one side of it in the mouth.

It will be noted that space closure or complete distal movement of cuspids will take longer in many cases when compared with apparent results of other methods or techniques. This will be true, of course, whenever the entire distance of movement or space closure is accomplished by distal movement of the cuspid, for any forward or mesial migration by teeth posterior to the space, simultaneous with cuspid movement, will reduce the time required for space closure correspondingly. I do not believe that the speed of

unobstructed physiologic tooth movement is proportional to the pressures applied.

It will be noted, also, as the distal movement of cuspids progresses and the appliance action continues, that, in many cases, the length of the original archwire becomes too great. This will be observed as an increase in the length of the ends of the arch as they extend distally through the last molar sheaths. When this occurs, the excessive length of the ends should be clipped off and replacement archwires should be made correspondingly shorter.

Whenever this phenomenon develops, it is explainable in two ways. Either the entire anterior section, including the central and lateral incisor teeth, is moving back with the cuspids as they go distally or the posterior units behind the extraction sites are moving mesially. From clinical observation, I believe that it is for the first reason that this occurs.

My reasoning is as follows: First, unless some of the ligature ties have been made too tight or some other error made in appliance construction or installation, there is no appreciable drag or mesial force exerted against the posterior units. Secondly, and most important, I have repeatedly observed this action or phenomena in cases where no coil section has been installed. With only a plain leveling arch in position, without incisor bands and without tie backs of any type, I see extraction spaces shrink until they are less than half their original dimension.

Under the circumstances, this could be due only to a natural mesial or forward migration of posterior units or a distal or posterior movement of the cuspids together with the incisor teeth.

If it is the posterior units coming forward, then I would consider that action unavoidable and unpreventable regardless of what methods and techniques were used. However, a natural improvement in the axial inclinations and the relations of anterior teeth together with a corresponding degree of facial improvement convinces me that this is where the improvement is taking place.

This is a profound illustration of the potential for improvement in the growth and developmental pattern of the structures that we are concerned with when the natural forces are unimpeded. This is also in harmony with the concept of correction by facilitation of normal growth and development.

For the retraction of central and lateral incisors, after the distal movement of cuspids has been completed, I use the conventional .020 wire with round closing loops distal to the lateral incisor brackets and cinched back to the molar units. The ends of this wire are tipped distally and lingually. I have not found that the resistance of the four anterior incisor teeth in the lower will displace anchorage units during this step in treatment; however, cervical anchorage may be used in order to reinforce posterior units if desired.

With respect to this use of cervical traction, I employ it to assist in the distal movement of cuspids in stubborn cases, particularly in the maxillary arch. This is done in conjunction with the use of the anterior coil section by engaging the hooks from the gear over the archwire in a manner which permits them to slide back against the cuspid brackets.

In a similar manner, it is employed directly against the cuspids, and through tooth contacts to the last molar teeth, as anchorage reinforcement for retraction of incisors. I also employ cervical traction in the retraction of upper central and lateral incisors by applying it to hooks or spurs on the archwire in the anterior region.

This method is safer, I believe, particularly if there is any great distance to move these teeth since there are no tie backs or reciprocal force against posterior units. If the patient doesn't wear the gear, there is no progress, but if these teeth are cinched back against the posterior units, they will come forward, especially in the upper arch, unless cervical reinforcement is faithfully applied against these teeth.

In the employment of the described technique, I believe that the natural forces are being followed to the maximum extent and that the end result will constitute the most natural harmony and balance for the individual case, and that stability after treatment with or without retention will be the ultimate attainable for the patient. I believe that the individual responses of the teeth and progress of the case in general will indicate the nature and the extent of the correction indicated for the individual case. It has been my experience that teeth move readily into their normal positions and relationships when unopposed and unobstructed. Hence, when the methods are correct, the progress is good.

When tooth movement is slow or stubborn and progress is frustrated, there are obstructions that must be overcome or the methods and objectives are wrong and are being opposed by the natural forces of occlusion. Thus, when the distal movement of cuspids slows down and becomes stubborn, there is either some functional interference or they have probably progressed as far distally as they should go. Whenever cuspids take on an excessive distal inclination, and this happens under the influences of the technique described, I am inclined to believe that they should not go any farther, and that the teeth should be uprighted with their crowns remaining in their attained relative positions.

Furthermore, when properly retracted and uprighted, I do not believe it should be necessary to tie back the cuspids during retraction of the central and lateral incisor teeth. If this is necessary, I believe it indicates an instability which will cause trouble later on in the case. I have never produced a dished-in face by these methods and my retention problems have been minimum. This convinces me of the clinical soundness of these methods.

With the complete retraction of the incisor teeth, the patient is ready for a rectangular ideal arch. The lower arch naturally precedes the upper in this respect because of the nature of incisor relations. In Class I cases, of course, this will be the finishing stage of treatment and requires no explanation on my part.

In cases where the complete space of the extractions is not needed for the positioning of the anterior teeth on apical base, there will be some space, of course, distal to the cuspids at this stage of treatment. If this space is considerable, and I am not concerned about getting my anterior teeth positioned too far lingually, I use a rectangular wire with vertical closing loops incorporated in the space to be closed and cinch the anterior section back against the posterior segments. If the space is small, or I am concerned about positioning my anterior teeth too far lingually, I will use a rectangular arch with tie back stops distal to the second bicuspid brackets or first molar brackets if second molars are engaged. I then use a series of tie backs at regular intervals, cinching the archwire back against the last molar teeth in order to close the space. This slower type of movement, I believe, is more considerate of the anterior segment.

Even in Class I cases, I find that many times some adjustment in occlusal relationships is necessary at the end of treatment. This is accomplished with Class II and vertical elastics, as in-

dicated, or triangular elastics may be employed.

In the preceding discussions, the basic principles of technique are those applied to individual tooth movement and arch formation in all classifications of malocclusion. In the treatment of Class II and Class III malocclusions, we have the additional factor of correcting the anteroposterior relation between the arches or apical bases when they are involved.

In the management of all Class II, Division 1 cases, I apply cervical traction to the maxillary arch. I will begin this in the mixed dentition stage or in the permanent dentition, depending upon the time at which the case presents. When the anterior teeth are crowded or overlapping, the cervical traction is applied directly to the first molars in the maxillary arch. If the upper incisors are protruding and spaced, I will apply the cervical traction directly to them at the beginning through Class II spurs on an archwire and continue until all spaces are closed in the anterior segment. From this point, the cervical traction will be applied to the molar teeth as well as the anterior by installation of molar stops. If possible, the cervical traction is continued until the Class II relationship has been reduced to Class I, after which the case is treated as a Class I malocclusion.

In Class II extraction cases with crowded anteriors cervical traction may be used directly against the upper cuspids in the retraction of these teeth after extraction of bicuspids. This traction may be continued against the cuspids and through them and through the contacts of all the posterior teeth until Class I molar relations are established, and continued during the retraction of central and lateral incisors. Or, after all space closure has been accomplished in the maxillary arch, the cervical traction is then applied to the archwire in the anterior region, with stops against the molars, continuing the distal traction upon the entire maxillary arch.

In a manner similar to the uppers, cervical traction may be applied to the lower cuspids in their retraction and continued during retraction of the central lateral incisors when this reinforcement is deemed necessary for the conservation of the anchorage units in their original positions.

When it appears that the cervical traction against the maxillary arch alone is not accomplishing the necessary adjustment between the arches in their anteroposterior relations, I will supplement the cervical force against the maxillary arch with Class II elastics. As a rule I do not utilize anchorage preparation in the mandibular arch excepting that provided to a degree by band placement and the leveling action of the appliances upon the posterior units as previously mentioned. Of course, I always have the second molars engaged in these situations and a rectangular stabilizing arch installed on the lower. It is my belief that, if the Class II relation stubbornly resists the combination of cervical traction to the maxillary arch and the Class II elastics, there is little use to attempt further distal positioning of the lower teeth or even to prevent them from coming forward. This is in line with my concept of following the natural forces and allowing them to indicate what the final adjustments must be. Again, I will say that, when the response to therapy is not ready and willing, either the plan of treatment and technique are wrong, some obstacle has been overlooked, or the patient is not cooperating.

In the management of Class II, Division 2 cases, cervical traction is applied directly against the cuspid brackets and through the contacts of the teeth to all the posterior units.

When sufficient posterior movement of these teeth has been accomplished to free the lateral incisors and the centrals, these teeth are engaged and brought into alignment. From this point leveling actions are continued in both arches accompanied by the necessary rotations. I always band second molars in these cases to facilitate the leveling action of the archwires in the lower and the compensating curve action of the archwires in the upper. Many of these bites are closed in the original malocclusion and all the length and leverage possible is needed in the archwires to overcome this.

When the bite has been opened and there is no occlusal or arch interference with the positioning of the teeth in Class I relation, I will institute Class I mechanics in conjunction with normal bite exercises to facilitate and stimulate the mesial correction of the lower in its anteroposterior relationship with the upper. These procedures first facilitate, then stimulate and guide the needed adjustment or correction. Since I consider the etiology of these cases muscular and likely to continue after treatment, I retain them by means of an upper Hawley with a flat anterior shelf lingual to the upper anteriors to maintain the bite opening or level and perhaps a cuspid to cuspid soldered lower lingual arch to insure the alignment of the lower incisor teeth. I have reason to believe that this is not always necessary.

In obtaining the needed anteroposterior correction in Class III malocclusion, my initial phase of treatment is directed toward establishing and maintaining a normal Class I incisal relationship of the anterior teeth. Cervical traction may be employed directly against the lower cuspids or the six lower anterior teeth as a unit in accomplishing this. Simultaneous forward expansion may be used in the upper. When normal anterior functional relations have been established in these cases, the remaining discrepancies in occlusal relations are treated symptomatically. Class III elastics without benefit of anchorage preparation are used at any stage of treatment. I consider that, in this type of case, the establishment and maintenance of normal functional relations of the upper and lower anterior segments are the guides for the positioning of the posterior units. Depending upon the degree of the Class III discrepancy, cervical traction, supplemented by Class III elastics, may be applied entirely against the anterior segment of the mandibular arch until all space closure has been accomplished or it may be stopped at any intermediate point, and the remaining space closed by rectangular arches with vertical closing loops cinched back against the last molar unit.

My first principle in treating this type of malocclusion is in following natural forces by establishing, first, the normal functional relations of upper and lower anterior segments and integrating the posterior units accordingly. Retention is of little importance in these cases except in maintaining expansion of the maxillary arch after correction of posterior crossbites.

In the preparation of this paper much has necessarily been left unsaid. I have endeavored to bring out the major principles of my ideology and clinical orthodontic practice and to outline the basic techniques employed to implement this ideology in practice. Detailed techniques are material for demonstration courses.

I reaffirm this ideology as follows: 1. No permanent improvements may be brought about in the management of malocclusion that exceed the limitations of the hereditary pattern for growth and development in the structures concerned as influenced by congenital factors, if any. 2. Our efforts

in the correction of malocclusions must be directed along the lines of adjusting environmental circumstances in all factors of occlusion with the objectives of facilitating, stimulating and guiding the growth and development of the structures concerned toward a maximum attainment of the individual hereditary limits. 3. For assurance in the attainment of these objectives, I believe it is best to plan techniques which avoid or minimize undesirable displacement of units permanently by reciprocal action inherent in appliance techniques. 4. Furthermore, it is my belief that the objectives and outlines of treatment are most faithfully pursued to the extent that dependence is not placed upon patient cooperation for the neutralization of dangerous reciprocal force. 5. For the most stable and natural harmony and balance attainable in the correction of a malocclusion it is best to follow the natural forces of occlusion as they affect the progress of the correction.

This is accomplished by the early removal of all impediments and interferences for normal positioning and functioning of the structures concerned. From this point the individual or mass movement of teeth in all their relations will proceed readily and with considerable ease when the objectives and techniques are correct and the patient is doing his part. I might say, in connection with this principle, that the teeth in all their relations tend to go where they should when permitted to do so. When treatment is directed toward first freeing and then stimulating and guiding these natural tendencies, the end results will be the best natural harmony and balance and the most stable correction.

In pursuing these principles, I strive for results at the end of treatment which anticipate a natural pattern of correction which would be that inevitable after the discontinuance of all retention. Confident of this, it has become standard procedure in my office, at the end of treatment, to remove all bands and archwires simultaneously and to continue observance of most cases without retention for a period of at least one year. This by no means implies that retention has become passe in my office. I continue to use it rationally when I feel there has been failure to neutralize all etiological factors — old or new — during the progress of the case. I cannot, however, feel that my responsibilities in any case are discharged with the installation of retainers. I merely consider that a new phase of treatment has been entered in such cases.

In closing, I wish to re-emphasize that the clinical achievements of Charles Tweed are my inspiration. It is through him, and with the kind cooperation of the other members of the Foundation, that I first perceived the most practical potentialities for orthodontic practice.

139 N. Vermilion St.

A Cephalometric Appraisal Of Class II And Class III Malocclusions

PROF. DR. GIORGIO MAJ, DR. CESARE LUZI, AND DR. PAOLO LUCCHESE

Bologna, Italy

The present knowledge of the facial dimensions and of the development of the jaws in Class II, Division 1 and Class III malocclusions is not yet definite owing to the different findings of various authors. The divergences are particularly remarkable in Class II, Division 1. Some authors (Sicher[1], Drelich[2], Gilmore[3], Blair[4], Mitchell[5]) have found the mandible underdeveloped, others (Adams[6], Renfroe[7], Altemus[8], Braun and Schmidt[9]) on the contrary, by comparing Class II cases with normal or Class I cases, have not found significant differences in mandibular size. These conflicting findings are possibly due to many reasons, of which the main ones are: 1) inadequacy of sampling (Krogman and Sassouni[10]); 2) difference in the methods of measurements and doubtful validity of the reference planes and points, the variability of which, added to the variability of the investigated phenomena, leads to scarcely significant and uncertain results; and 3) too fractioned analysis, each skeletal component being measured independently of the others.

Actually, great importance is due not only to the correlation among the different skeletal components, but also to the relationship between the skeletal pattern and inclination and position of teeth of the two arches. Indeed, an orthognathic skeletal type (straight profile) may be harmonious or inharmonious in an individual case according to the axial inclinations of the lower and upper incisors. The opposite conditions apply to the prognathic skeletal type (angular profile).

We have examined the skeletal and dental relationships in fifty cases of Class II, Division 1 and fifty cases of Class III malocclusions by means of a method of cephalometric analysis we have already reported[11].

METHOD OF ANALYSIS

Our method differs from the majority of the others in two ways: 1) it does not consider any reference plane taken outside the masticatory apparatus, and 2) it tries to correlate the values of the various chosen ratios in order to obtain a resultant which can indicate whether we are dealing with a harmonic or disharmonic faciodental type, taking into consideration the different types of head construction (prognathic, mesognathic and orthognathic).

It is based chiefly on the correlation among the values of the four main factors which influence the overjet. They are as shown in Figure 1: 1) Bony base ratio, given by the difference between the lengths of two lines drawn from the extreme point of the mandibular condyle, one to the farthest point of the chin and the other to the anterior nasal spine (CoM - CoANS). 2) Inclination of the mandible, determined by the angle ANS-Co-M. 3) Axial inclination ratio of the anterior teeth, the difference between the degree of axial inclination of the lower incisor and the degree of axial inclination of the upper incisor on the ANS-Co-M angle bisector. 4) Distance between the upper and lower incisor apices in projection on the ANS-Co-M angle bisector.

Fig. 1. Measures adopted in cephalometric analysis of the authors. The maxillodental formula results from the following ratios: 1, Difference CoM-CoANS; 2, Angle ANS-Co-M; 3, Difference of the angles that the lower and upper incisors' axes form with the bisectors of the angle ANS-Co-M; 4, Distance between the apices of the upper and lower incisors in projection on the bisector of the angle ANS-Co-M. Development and position of the mandible are given by the following measurements: 1, Length Co-M; 2, Angle Co-M-Go; 3, Angle M-Co-Go; 4, Angle M-Go-Co; 5, Distance Ba-Co in projection on the line ANS-Bolton point. The position of the anterior teeth with reference to their respective bases is given by the following measurements: 1, Projection of the distance Incision-ANS on the ANS-PNS line; 2, Angle that the upper incisor axis forms with ANS-PNS line; 3, Projection of the distance lower Incision-M on the line M-Go; 4, Angle that the lower incisor axis forms with M-Go line.

The above four ratios have been measured on the lateral headplates of 220 subjects of age varying between eight and fifteen years. The subjects were untreated and characterized by general harmony of the face and normal occlusion of the teeth. The data obtained have been mathematically and statistically elaborated by the method of the Standard Binomial Polygons by Frassetto[12] which consists of making the percentage and perequation of the raw frequency polygon and, after having found out the modal value, in dividing such polygon in three areas, the central one which (called the medionormal or paranormal values) contains 66.68 per cent of the observation, and the two side ones (called the distonormal values, respectively lower and upper) each contain 16.62 per cent (Fig. 2). This method has been chosen because it permits examination with greatest accuracy of the asymmetric distributions of the characters. His central area is almost equal to the plus or minus one standard deviations area. The whole of these three areas represents the range of the normal variations of the examined character.

The data of this statistical elaboration are summarized in Table 1.
In order to establish whether the combination of the values of these four ratios gives origin to a well-balanced whole or not, it is necessary: 1) to translate the deviations from the average values of each ratio into units equivalent in determining the degree of overjet; 2) to give to the deviations from the average value of each ratio a positive or negative sign, according to their aim to increase (positive sign) or to decrease (negative sign) the overjet.

In determining the influence that the above four factors have in the production of the overjet, we have found that the deviation of one mm in linear

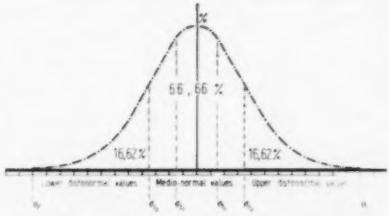

Fig. 2. Schematic representation of the area tripartition following the Standard Binomial Polygons method by Frassetto.

TABLE I

	Difference CoM - Co ANS			Angle ANS - Co - M			Difference in inclination of incisors			Distance between projected apices of incisors		
Age in years	8- 9	11-12	14-15	8- 9	11-12	14-15	8- 9	11-12	14-15	8- 9	11-12	14-15
Range of normal variation	7-29 mm	8-30	12-32	26°-44°	26-44	26-42	35°-67°	26-67	32-68	8-23 mm	3-26	8-23
Modal value	18 mm	19	22	35°	34	34	51°	46	50	16 mm	15	16
Paranormal values	15-21 mm	16-22	19-25	32°-38°	32-37	32-36	46°-56°	40-52	45-55	14-18 mm	12-18	14-18
Inf. distonormal values	7-14 mm	8-15	12-18	26°-31°	26-31	26-31	35°-45°	26-39	32-44	8-13 mm	3-11	8-13
Sup. distonormal values	22-29 mm	23-30	26-32	39°-44°	38-44	37-42	57°-67°	53-67	56-68	19-23 mm	19-26	19-23

Statistical data of the four ratios which make the maxillodental formula.

measurements is equivalent to two degrees in angular measurements. Therefore the value of 1 is given to a deviation of one mm in the first and fourth ratios and the value of 0.5 to one degree in the second and third ratios. As the average value of each ratio is equal to zero, a positive value is given to the variations below the average value of the anteroposterior ratio of the bases and a negative value to the variations above average. A positive value is given to variations above the average value for the angle ANS-Co-M and a negative value to variations below average. A positive value is given to the variations above average for the inclination ratio of the incisors, and a negative value to those below average. A positive value is given to the variations below average for the distance between the projection of the incisal apices on the bisector of the angle ANS-Co-M and a negative value to variations above average.

The formula used is outlined in Table II.

Taking the sum of the four values obtained in each normal individual, we obtain a total of between + 6 and — 5, with an average value of + 0.5. This range, however, is very much reduced if it is considered with reference to the different constitutional types of

TABLE II

	Average Value (8-9 years)	Displacements from Average Value
Difference CoM-CoANS	18 mm. = 0	± 1 mm. = ∓ 1
Angle ANS - Co - M	35° = 0	± 1° = ± 0.5
Difference of incisal inclination on bisector of ANS-Co-M	51° = 0	± 1° = ± 0.5
Distance projected apices on bisector of ANS-Co-M	16 mm. = 0	± 1 mm. = ± 1

TABLE III

	Total mandibular length			Angle Co - M - Go			Angle M - Co - Go			Angle M - Go - Co		
Ages	8-9	11-12	14-15	8-9	11-12	14-15	8-9	11-12	14-15	8-9	11-12	14-15
Range of normal variation	89-111 mm	91-118	98-128	16°-30°	16-30	16-30	22°-38°	25-39	24-38	112°-142°	111-136	110-136
Modal value	100 mm	104-105	113	23°	23	23	30°	33	32	127°	123-124	123
Paranormal values	97-103 mm	100-109	108-118	21°-25°	21-25	21-25	28°-32°	31-35	30-34	123°-131°	119-128	118-128

Statistical data of the mandible measurements.

head. In the normal subjects of the prognathic type, the total values vary from + 6 to — 1.5, in those of mesognathic type from + 5 to — 2, and in those of orthognathic type from + 2 to — 5.

The analysis is completed with a series of complementary assessments, Assessment of the development and position of the mandible, of the position of the foremost point of the upper jaw with reference to the mandibular condyles and finally, of the position of the anterior teeth with reference to their respective bases.

The assessment of the size and shape of the mandible is made by the following measurements:

1) Total length is the distance existing between the condyle and the mental eminence.

2) Angle Co-M-Go indicates the relative development in the height of the rami.

3) Angle M-Co-Go gives the relative development in length of the mandibular body.

4) Angle M-Go-Co shows the degree of tilting of the body of the mandible on the rami.

The data of the statistical elaboration of these measurements in 220 normal children are summarized in Table III.

The position of the mandible is determined by making two measurements:

1) Angle ANS-Co-M, which indicates the tilting of the mandible.

2) The distance between basion and the most posterior point of the condyle in projection on the line ANS - Bolton point. This distance indicates the anteroposterior position of the condyles with reference to the cranial base.

The statistical data concerning angle ANS-Co-M have been reported in Table I. The ones concerning the distance between basion projection - condyle projection on Bo-ANS line are summarized in Table IV.

The position of the foremost point of the upper jaw with reference to the mandibular condyles is established by measuring the length of the ANS-Co line. The statistical data of this distance are also summarized in Table IV.

The positions of the front teeth are established by taking the following measurements:

TABLE IV

	Distance basion-condyle in projection on Bo -ANS			Distance condyle-ANS		
Ages	8-9	11-12	14-15	8-9	11-12	14-15
Range of normal variation	2-13 mm	2.5-16	1.5-13.5	69-95 mm	71-99	76-105
Modal value	7.5 mm	8	7.5	82 mm	85	90
Paranormal values	6.9 mm	6-10.5	5.5-9.5	77-87 mm	80-90	85-96

Statistical data of the measurements giving the anteroposterior position of the mandible and the position of the foremost point of the upper jaw.

1) Distance of incision (in projection on the ANS-PNS line) from the anterior nasal spine, and the angle that the upper incisor axis forms with the ANS-PNS line.
2) The distance of inferior incision (in projection on the M-Go line) from the point M, and the angle that the lower incisor axis forms with the M-Go line.

The statistical data of these four measurements are summarized in Table V.

Findings

A. *Skeletal and dental relationship in Class II, Division 1 cases.*

Fifty subjects of both sexes of age varying between eight and fifteen years have been examined. In all cases the maxillodental formula shows remarkably higher values than those which are found in normal subjects of the prognathic type (Fig. 3). They vary from + 9 to + 22.5. Table VI summarizes the distribution of the

TABLE V

	Distance ANS-Incision			Angle superior incisor-ANS-PNS plane			Distance M point - inferior Incision			Angle inferior incisor — M-Go plane		
Ages	8-9	11-12	14-15	8-9	11-12	14-15	8-9	11-12	14-15	8-9	11-12	14-15
Range of normal variation	-9 to +3.5 mm	-10 to +9	-10 to +9	94°-124°	94-124	94-124	0-15 mm	0.5-16	0-17	79°-107°	80-112	80-110
Modal value	-3 mm	-1	-1	109°	109	109	7.5 mm	8	8.5	93°	97	95
Paranormal values	-5 to -0.5 mm	-3 to +1.5	-3 to +1.5	105°-113°	105-113	105-113	5.5-9.5 mm	5.5-10.5	6-11	89°-97°	92-101	90-100

Statistical data of the measurements giving the positions of both upper and lower incisors in relation to their respective bases.

Difference MCo - ANS Co = 13 mm = + 5
Angle ANS - Co - M = 39° = + 2
Difference axial inclination of incisors - 72° = + 10,5
Distance apices projection = 14 mm = + 2
+ 19,5
ANS
V. G - ♂ - 8 YR
M

Fig. 3.

values found in the various determinations.

To establish the real depth of the face, the length of the ANS-Ba line has been measured, because the ANS-Co line, which gives the position of the foremost point of the upper jaw with reference to the mandibular condyles, is disturbed by the variability of position of them on the cranial base. From the above reported data it is possible to draw the following deductions in Class II, Div. 1 cases. (1) The small difference in the ratio of the bony bases found in sixty-two per cent of the cases is possibly due to a considerable depth of the middle face which leads to a relatively forward position of the upper jaw, or to a

TABLE VI

	Inferior disto-normal values (%)	Para-normal values (%)	Superior disto-normal values (%)	High extra normal values (%)
Difference CoM-CoANS	62	16	2	
Angle ANS-Co-M	10	48	38	4
Diff. axial inclin. front teeth	6	36	54	4
Distance incis. Apices projection	76	4		
Length Co-M	26	52	22	
Length Co-ANS	4	58	38	
Length Ba-ANS	4	62	34	
Length Ba-Co	24	64	12	
Angle Co-M-Go	8	72	20	
Angle M-Co-Go	18	58	24	
Angle M-Go-Co	26	62	12	
Distance ANS-Incision	8	52	36	4
Angle sup. incisor-ANS-PNS plane		18	42	20
Distance M point-inf. Incision	10	74	14	2
Angle inf. incisor M-Go plane	12	62	26	

Per cent distribution of the values of the different measurements in fifty cases of Class II, Division 1 malocclusion. The only low extra normal value was 20, the projected apices of the incisors.

backward positioning of the mandibular condyles.

The total mandibular length shows instead about the same statistical behavior found in normal subjects of corresponding age. The relative development of the rami and body and also the gonial angle do not show noteworthy differences. However, small values of the gonial angle are more frequent than great values.

The lower jaw is further found remarkably inclined in more than one third of the cases.

It appears therefore justified to state that the reduced difference in the bony base ratio found in Class II, Div. 1 cases is not due to an abnormal development of the various parts considered separately, but due to an abnormal topographic ratio or to their unbalanced combination.

Our findings validate, therefore, the statement of Brodie[13], shared by Wylie[14] and by Kloehn[15] that: "Malocclusion with the exception of those traceable to local environmental causes becomes the visible symptom of inharmonious relationship between parts closely adjacent to or quite remote from the mouth proper, and such disharmony apparently can be traced only to the chance operation of genetic laws."

(2) The inclination ratio of the incisors shows a typical behaviour because in fifty-eight per cent of the cases the values are higher than the upper limit of the paranormal values, and also in almost all the remaining cases is such as not to compensate the small difference in the bony base ratio. The great difference in the inclination ratio of the front teeth is due in seventy-eight per cent of the cases to a considerable proclination of the upper incisors, in ten per cent to an upper proclination combined with a lower retroclination, and in twelve per cent only, to a retroclination of the lower incisors. In fourteen cases (twenty-eight per cent) the axial inclination of the lower incisors on the mandibular plane is increased.

(3) The relative anteroposterior position of the upper and lower incisor apices is, in ninety-six per cent of the cases, remarkably close (in twenty per cent quite beyond the lower limit found in normal subjects of corresponding age) showing that the position of the anterior teeth, in their relative bases, not only does not compensate the small difference in the bony bases ratio, but instead exaggerates it, increasing the overjet.

(4) Class II, Division 1 malocclusion seems, therefore, to be the result of a series of skeletal and dental variations which, although generally remaining within the limits of the normal range of variation, show a behavior in the prognathic direction; that is, all concur, although in a different degree, to increase the overjet. This explains the reason for the discordant findings of the authors who have studied the various parts separately, and confirms the need that the investigation of a malocclusion must be based on the correlation of all the skeletal and dental ratios to draw useful indications for the prognosis and treatment planning.

B. Skeletal and dental relationships in the Class III cases.

Fifty subjects of both sexes of age varying between eight and fifteen years have been examined. In all cases the maxillodental formula gives more negative values than those which are found in the normal subjects of orthognathic type, from —7 to —23.5 (Fig. 4). Table VII summarizes the distribution of the values found in the various measurements. The following deductions can be drawn from the above data.

(1) The great difference in the bony base ratio which is found in the great majority of observations (seventy-eight

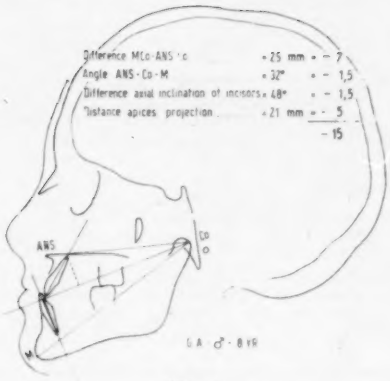

Fig. 4.

per cent) is due mainly to two factors; an increase in the total length of the lower jaw or a forward position of mandibular condyles with reference to the cranial base. The former factor prevails.

The increase in size of the mandible is not proportional in its parts, but is mainly due to overdevelopment of the mandibular body. In fact, the increase in total length is associated with a reduction of the Co-M-Go angle, which gives the relative development in height of the rami and an increase of the M-Co-Go angle, which gives the relative development in length of the body, while the gonial angle is not disturbed. And further the lower jaw shows, in about one fourth of the cases, a very small inclination.

(2) The inclination ratio of the incisors has been found to be normal in about half of the cases, while the other half shows high values with the exception of a small minority charac-

TABLE VII

	Inferior disto-normal values (%)	Para-normal values (%)	Superior disto-normal values (%)	High extra-normal values (%)
Difference CoM-CoANS	2	20	62	16
Angle ANS-Co-M	24	72	4	
Diff. Axial inclin. front teeth	10	44	36	10
Distance incis. apices projection			72	22
Length Co-M	2	48	38	12
Length Co-ANS	16	72	12	
Length Ba-ANS	14	76	10	
Length Ba-Co	6	60	34	
Angle Co-M-Go	32	64	2	
Angle M-Co-Go	14	56	28	2
Angle M-Go-Co	12	66	20	2
Distance ANS-Incision	20	60	20	
Angle sup. incisor-ANS-PNS plane	22	46	32	
Distance M Point-inf. Incision	6	50	40	4
Angle inf. incisor M-Go plane	48	34	6	

Per cent distribution of the values of the different measurements in fifty Cases of Class III malocclusion. The only low extra normal values were Angle Co-M-Go of 2, and inferior incisor to M-Go plane of 12.

terized by low values. This great difference of inclination of the front teeth is due to a lower retroclination, while the axial inclination of the upper incisors remains within the normal limits. The statistical behavior of this ratio shows, therefore, an opposite direction to the one of the skeletal ratios referred to above, as it aims to reduce the amount of the anterior crossbite caused by unfavorable bony base ratio.

(3) The relative anteroposterior position of the incisor apices shows that in ninety-four per cent of the cases the distances between the apices is exaggerated. This ratio is therefore definitely unfavorable.

(4) The skeletal and dental pattern of the cases of Class III malocclusion, is, in its general lines, similar to the normal orthognathic type from which it differs for the great amount of the negative values in the bony base ratio, and in the distance between the incisor apices.

Via Marsili 15

REFERENCES

1. Sicher, H.: The Growth of the Mandible. *Am. J. Ortho. and O. Surg.*, 33:30, 1947.
2. Drelich, R. C.: A Cephalometric Study of Untreated Class II, Division 1 Malocclusion. *Angle Ortho.*, 18:70, 1948.
3. Gilmore, W. A.: Morphology of the Adult Mandible in Cl. II, Div. 1 Malocclusion and in Excellent Occlusion. *Angle Ortho.*, 20:137, 1950.
4. Blair, E. S.: A Cephalometric Roentgenographic Appraisal of the Skeletal Morphology of I, II (1) and II (2) (Angle) Malocclusions. *Angle Ortho.*, 24:106, 1954.
5. Mitchell, D. J. E.: The Mandibular Morphology of Distoocclusion. *Am. J. Ortho.*, 40:232, 1954.
6. Adams, J. W.: Cephalometric Studies of the Form of the Human Mandible. *Angle Ortho.*, 18:8, 1948.
7. Renfroe, E. W.: A Study of the Facial Patterns Associated with Class I, Class II, Division 1 and Class II, Division 2 Malocclusions. *Angle Ortho.*, 18:22, 1948.
8. Altemus, L. A.: Horizontal and Vertical Dentofacial Relationships in Normal and Class II Division 1 Malocclusion in Girls 11-15 Years. *Angle Ortho.*, 25:120, 1955.
9. Braun, N. L., Schmidt, W. G.: A Cephalometric Appraisal on the Curve of Spee in Class I and Class II (1) Occlusions for Males and Females. *Am. J. Ortho.*, 42:255, 1956.
10. Krogman, W. M., and Sassouni, V.: A Syllabus in Rcentgenographic Cephalometry, Philadelphia, 1957. Philadelphia Center for Research in Child Growth.
11. Maj, G., Luzi, C., Lucchese, P.: A New Method of Cephalometric Analysis Suitable for the Different Constitutional Types of Head. *Dent. Practit.*, 8:358, 1958.
12. Frassetto, F.: Tables pour la représentation graphygue des Polygones binomiaux standard symétriques. *S. A. S.*, 3:1, 1936.
13. Brodie, A. G.: Facial Patterns, a Theme on Variations. *Angle Ortho*, 14:75, 1946.
14. Wylie, W. L.: The Assessment of Anteroposterior Dysplasia. *Angle Ortho*, 17:97, 1947.
15. Kloehn, S. J.: A New Approach to the Analysis and Treatment in Mixed Dentition. *Am. J. Ortho.*, 39:161, 1953.

Identification Of Landmarks In Cephalometric Radiographs

PETER K. J. YEN, D.M.D.*

Boston, Massachusetts

For the past twenty-eight years skull radiography has been used extensively in both clinical orthodontics and research. In order to interpret these radiographs, an adequate understanding of radiographic anatomy is essential.

Anatomical details on radiographs are often obscured by overlapping images of individual bones and by differences in their thickness and density, which makes the interpretation of skull radiographs difficult.

The radiographic image produced by a dry skull is more distinct than one obtained from the head of a living person, thus facilitating the identification of anatomical features. Etter[1] disarticulated a skull to make radiographs of individual bones. With the knowledge obtained, he was able to recognize many lines and shadows on an image of the entire skull.

A study of the atlases of Etter[1] and Goldhamer[2] contributes to an understanding of radiographic anatomy. However, the interest of the orthodontist is focused primarily on the development of the maxilla and mandible as related to the development of the cranium, while the radiologist is more interested in pathology. Skull radiographs in norma frontalis and lateralis, taken by the orthodontist with the aid of a cephalostat, also differ from the projections favored by the radiologist. It is necessary, therefore, to obtain specific information for the orthodontist to facilitate interpretation of cephalometric radiographs of the living.

Krogman and Sassouni[4] have already presented valuable descriptions of landmarks in cephalograms, but an attempt has been made in the present study to obtain more detailed information of particular value for the research worker interested in growth and development.

METHODS

A dry skull was positioned in a Broadbent cephalostat and radiographed in norma frontalis and norma lateralis. In order to identify the many lines and shadows, a series of radiographs was made of this skull after successive applications of a radiopaque paste, consisting of amalgam shavings and vaseline, to various bony ridges or landmarks and around different foramina on the right side of the skull. The untouched left side was studied and compared with the right side.

Radiographs of a living subject were obtained also, and landmarks were identified with the aid of the radiograms of the dry skull.

The definitions of anthropometric landmarks by Martin and Saller[5] were used in this study and *Gray's Anatomy*[3] has been followed for nomenclature.

FINDINGS

Norma Lateralis (Figs. 1 and 2)

The semicircular outline of the sella turcica can be divided into three parts; anteriorly the tuberculum sellae (1) dorsal to the chiasmatic groove, cen-

*Instructor in Dental Medicine, Harvard School of Dental Medicine. This project was conducted during the author's tenure as Fellow in Orthodontics at the Forsyth Dental Infirmary, Boston, Massachusetts.

Fig. 1.

trally the saddle or sella proper (2) where the hypophysis is lodged, and posteriorly the dorsum sellae (3). Radiographically, the tuberculum sellae and dorsum sellae may form a continuous shadow with the anterior (4) and posterior (5) clinoid processes, respectively, but in most instances the latter can be clearly distinguished. The opaque image of the anterior clinoid process and the mesial half of the edge of the lesser wing (6) of the sphenoid bone form a continuous outline. The roofs of the orbits (7) can be readily identified in the radiograph.

The sphenoid planum (8) containing the chiasmatic groove is ventral to the tuberculum sellae and extends forward into an image of a bony ridge formed by the lateral margin of the ethmoid and the frontal bone (9). Below, the cribriform plate of the ethmoid bone can be seen as a faint line (10). The outline of the posterior clinoid processes continues caudally and dorsally to the spheno-occipital synchondrosis (11) which becomes ossified in later life, and it terminates at basion (12) — the lowermost point on the anterior margin of the foramen magnum in the sagittal plane. Basion can sometimes be located readily by its proximity to the tip of the odontoid process(13) of the second cervical vertebra (14). The ventral surface of the basilar part (15) of the occipital

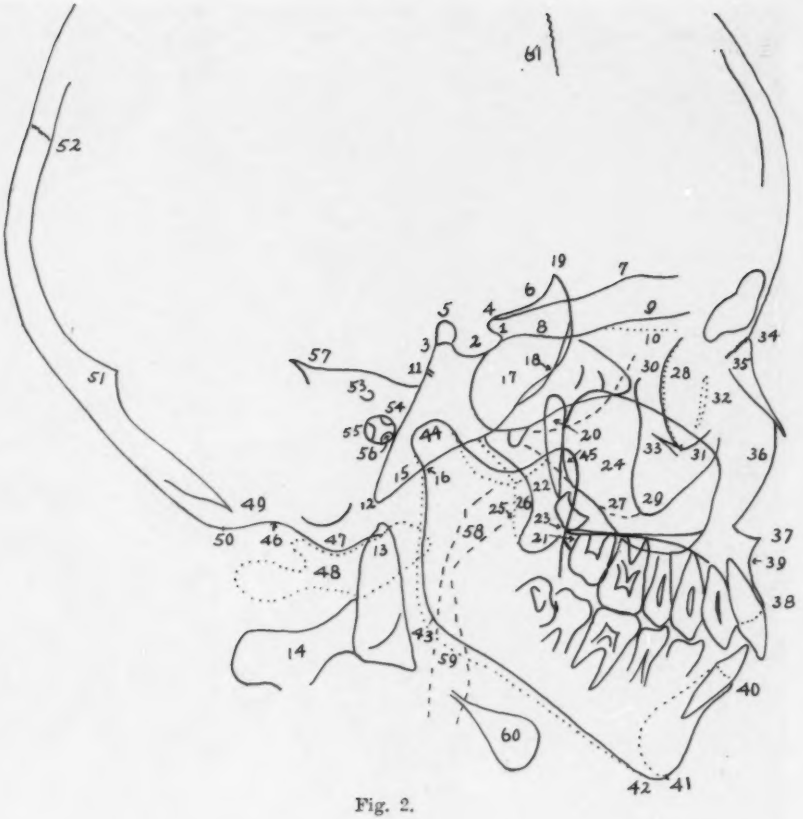

Fig. 2.

bone intersects the posterior border of the mandibular ramus at a point which Björk named articulare (16).

The sphenoidal sinus (17) is situated immediately beneath the sella turcica. It often consists of several compartments. The anterior wall of the middle cranial fossa (18) shows as an opaque line. The radiographic projection of the middle cranial fossa forms a continuous line with the lateral edge of the lesser wing of the sphenoid bone (19).

The pterygomaxillary fissures (20) are slender and triangular-shaped shadows, and they are formed by the maxillary tuberosities (21) and pterygoid processes (22). The posterior nasal spine (23) is frequently obscured by the unerupted permanent maxillary molars. However, it can be located at the point where the hard palate is intersected by an extension of the pterygomaxillary fissures. Anterior to the pterygomaxillary fissure is the maxillary sinus (24), and posterior to this fissure are the lateral (25) and medial (26) pterygoid plates.

The outline of the zygomatic arch (27), the posterior border of the orbit (28), the zygomatic process of the maxilla or key ridge (29), the frontal

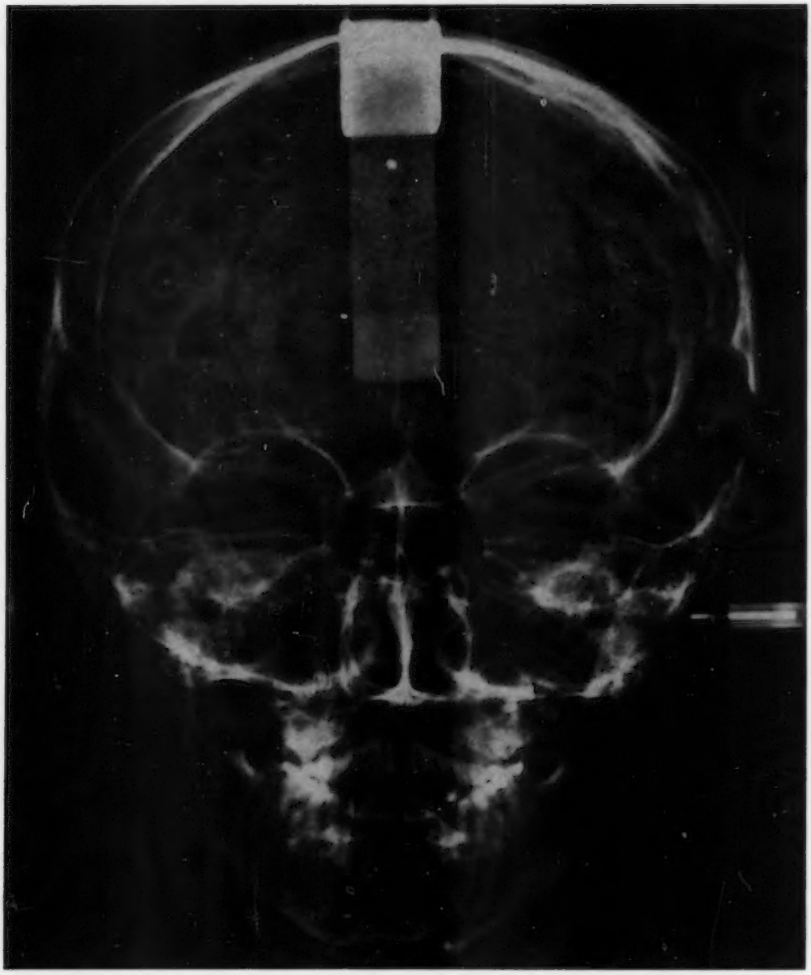

Fig. 3.

process of the zygomatic bone (30), the infraorbital ridge (31) and the lacrimal notch (32) can also be identified. The anterior half of the infraorbital groove (33) can sometimes be seen inside the outline of the maxillary sinus.

Nasion (34) is the most anterior point of the frontonasal suture, which runs obliquely upward and forward. From nasion downward the following anatomical landmarks can be seen: the outline of the nasal bone (35) and the nasal notch (36) of the maxilla, the anterior nasal spine (37), prosthion (38) — the intersection of the alveolar process and the maxillary central incisors — and subnasale (39) which is

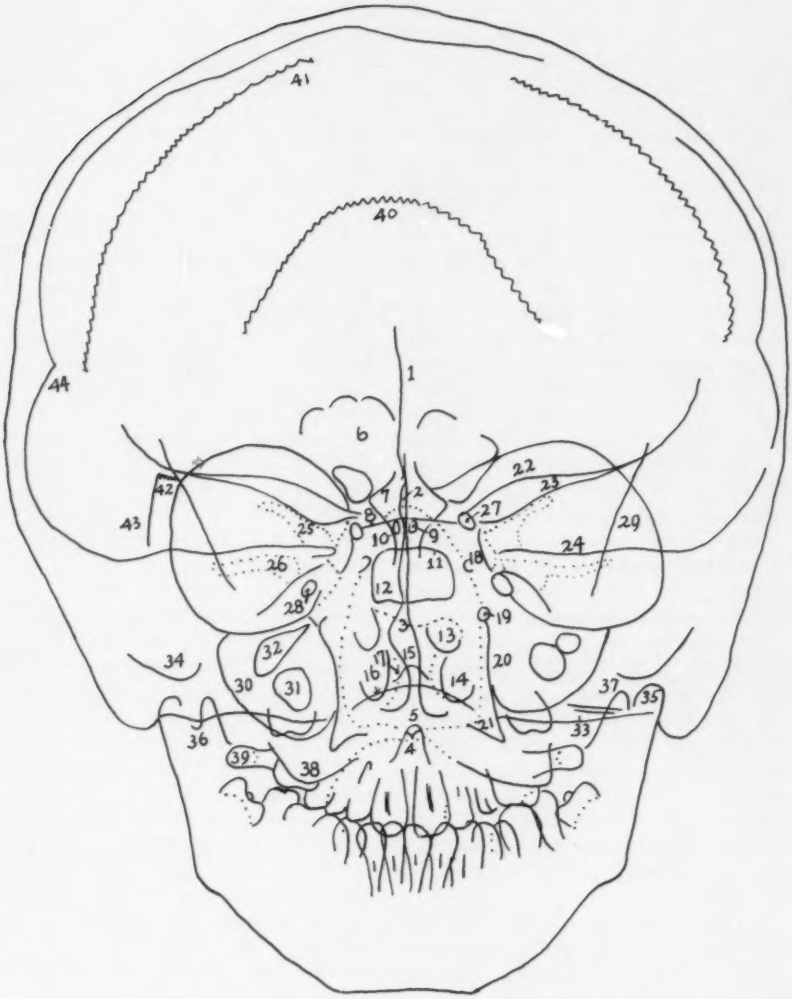

Fig. 4.

the deepest point of the curved outline from anterior nasal spine to prosthion.

In the mandible, infradentale (40), the intersection of the alveolar process and the mandibular central incisors, pogonion (41) — the most prominent point of the chin, gnathion* (42) — the lowest point on the mandible where the curvature of the chin becomes confluent with the base, and gonion (43) — the most inferior and posterior point

*Some confusion exists regarding the definition of gnathion and menton as discussed by Krogman and Sassouni[4].

at the mandibular angle — can be distinguished. By following the continuous outline of the ramus, the condyloid (44) and coronoid processes (45) can be traced readily.

The Bolton point (46), the intersection of the occipital condyle (47) and the outline of the foramen magnum, can be located at the deepest point of the curve posterior to the occipital condyle which rests on the articular surface of the atlas (48). Opisthion (49) can be located at the midpoint of the posterior margin of the foramen magnum, situated above the floor of the posterior cranial fossa (50). The internal occipital protuberance (51) and the lambdoid suture (52) can be traced by following the intracranial surface of the occipital bone upward from opisthion.

The internal acoustic meatus (53) is situated superiorly to the external meatus. The latter consists of three radiolucent areas, the fenestrum vestibulae (54) situated superiorly, the fenestrum cochlea (55) posteriorly, and the promontory (56) anteriorly. The promontory is a round eminence of very thin bone curved by the first coil of the cochlea. Above the internal meatus the superior ridge of the pyramid of the temporal bone (57) can be located. It intersects the dorsal surface of the basilar part of the occipital bone.

The retropharyngeal space (58) and the oesophagus (59) give a radiolucent shadow crossing the ramus and the gonial angle of the mandible.

Norma Frontalis (Figs. 3 and 4)

From the vertex down, the head is divided into two halves by a vertical line which is composed of the images of the frontal crest (1) where the falx ceribri is attached, the crista galli of the ethmoid (2), the nasal septum (3), the anterior nasal spine (4), the odontoid process of the second cervical vertebra (5) and the midlines of the maxillary and mandibular dentitions. Structures on either side of this line can be identified at different levels. The frontal sinuses (6) are situated on both sides of the frontal crest, and the outer boundary of the lamina cribrosa or cribriform plate (7) is seen on either side of the crista galli.

At a lower level the horizontal opaque image of the sphenoidal planum (8), the openings of sphenoidal sinus (9), the ethmoid labyrinth (10), the floor of the sella turcica (11) and the boundary of the sphenoidal sinus (12) can be distinguished. The middle (13) and the inferior turbinate (14) bones are situated opposite the lower half of the nasal septum (15), composed of the crests of maxilla and palatine bones. Basion (16) and opisthion (17) are visible at the level of the inferior turbinate (14).

Along the outer boundary of the nasal cavity, the opening of the ethmoidal sinus (18), the sphenopalatine foramen (19), the pterygoid plate (20) and the hamulus (21) can be located.

In the orbital region, the roof of the orbit (22) and the posterior edge of the lesser wing of the sphenoid bone (23) sometimes give overlapping shadows as they extend laterally. The superior ridges of the pyramids of the temporal bones (24) not only divide the orbits approximately into two halves, but also the height of the entire head. The superior (25) and the inferior (26) orbital fissures are located above and below the pyramidal part of the temporal bones, respectively. Along the medial margin of the orbit, the optic foramen (27) and the foramen rotundum (28) can be seen. The temporal line (29), an opaque shadow crossing the orbit obliquely, is produced by the medial wall of the temporal fossa.

In the region of the maxillary sinus (30), the jugular foramen (31) and

the foramen lacerum (32) can be readily identified. The floor of the posterior cranial fossa (33) either passes through the maxillary sinus or below its floor depending on the size of the sinus. The inferior border at the junction of maxilla and zygomatic bone (34) is located above the mandibular condyle (35), the sigmoid notch (36) and the coronoid process (37). The atlas is composed of a lateral mass (38) and transverse processes (39). The lambdoid (40) and coronal (41) sutures can be distinguished at different levels in the vertex, the latter lying above the former. The frontozygomatic suture (42) and the frontal process of the zygomatic bone (43) are observed lateral to the orbit. Following the pyramidal ridge of the temporal bone, a ridge (44) composed of the internal surfaces of frontal, a greater wing of sphenoid, temporal and parietal bones is readily observed.

SUMMARY

A method has been described to identify the radiographic images of landmarks in the dry skull. The knowledge obtained can be applied to studying cephalograms of the living. Various anatomical landmarks seen in radiographic projections of the skull both in norma lateralis and frontalis, have been described and identified.

140 The Fenway

BIBLIOGRAPHY

1. Etter, L. E.: 1955 Atlas of Roentgen Anatomy of the Skull. *Charles Thomas*, Springfield, Illinois.
2. Goldhamer, K.: 1931 Normal Anatomy of the Head as Seen by X-ray. Vol. 1 and II, *Georg Thieme*, Leipzig, 1930.
3. Gray, H.: 1954 Anatomy of the Human Body, edited by C. M. Goss, *Lea and Febiger*, Phildelphia, Pennsylvnia, 26th ed.
4. Krogman, W. M. and V. Sassouni: 1957 A Syllabus in Roentgenographic Cephalometry. *Philadelphia Center for Research in Child Growth*, Philadelphia, Pennsylvania.
5. Martin, K. and K. Saller: 1956 Lehrbuch der Anthropologie. *Gustav Fisher* Verlag, Stuttgart, 3rd ed.

Phylogenetic Forces Of Growth

GEORGE H. PREWITT, D.D.S., M.S.
Lexington, Kentucky

Claude Bernard held that life was a creative force which developed and exhibited itself through organization and expressed itself in biological, physiological, and chemical phenomena. His fame, however, lies in the fact that he contributed a methodology for experimental study which expounds the consideration of all known facts leading to a theory which subsequently can be verified scientifically. When experimental data fails to support the hypothesis, the investigator must either produce new evidence or initiate a new approach to the problem.[1]

Ehrlich who capitalized upon an archaic therapeutic principle in treating disease was among the first to succeed in proving that living matter could be altered chemically. It was his investigative persistence which led to a modification of an arsenical compound demonstrating the effectiveness of chemicals when discriminately introduced into living tissue.

Since then, other chemotherapeutic agents including sulfonamides became available. In this instance, a chemical agent is able to modify metabolism by interfering with bacterial nutrition. Penicillin, a vegetative mold, is capable of destroying a unit of living material by chemical alteration.

These events are mentioned to emphasize the importance of methods employed for modification of living material.

A different example concerning the chemical nature of life was demonstrated when it was shown that genes act by affecting specific enzyme systems. In an experiment by Tatum and Beadle, bread mold was bombarded with radiation until this mold was unable to produce its normal quota of necessary amino acids. The authors concluded that radiation had altered or destroyed specific genetic activity.[2]

Further evidence of chemical importance in nature is the ability of desoxyribonulecic acid to produce genetic changes. The absorption spectrum of DNA is such that the energy which it can absorb from ultraviolet light is effective in modifying heredity.

(The DNA content of the nucleus is constant for the species, and within a given species related to the number of chromosomes. It doubles in quantity if the nucleus is to divide[3].)

These data lend support to the chemical energy nature of living material. It is plausible that living matter originated from complex molecules of a type which could sustain reactions sufficiently long to determine and maintain species, yet allow for small additional absorptions in the form of mass or energy from light. This then gradually could change the heredity and destiny of the species.

(Einstein showed that mass was equal to speed of light squared; thus light, mass, and energy are physically interchangeable. Speed or velocity by definition involves the factor of Time.)

To understand the physiochemistry of living matter, it is necessary to review the origin of life.[4] When life first began on this cooling planet, apodictic combinations and permutations of matter inherently acquired fundamental regulations for survival which we call the "Biological Imperatives". Living units can endure only as long as this set of rules is maintained.

Read before the Mid-Western Component of the Angle Society, Chicago, 1959.

Let us for a moment consider the origin of basic chemicals. Either they came to the earth intact or they gradually evolved from elements by mutations in molecular structures. It is probable that both situations occurred, but the sun and solar system is known to consist mainly of hydrogen. It seems logical, therefore, to consider that all matter originated from hydrogen with all the other elements being derived through a series of molecular energy reactions.

One further consideration deserves mention. By a seven stage reaction, the sun converts hydrogen into helium and releases energy. At a higher end of the periodic table we note that lead can result from a breakdown (half-life) of the unstable atom of radium. This is so mathematically constant that the lead ratio is used to label rocks as Carbon 14, a method utilized for dating living material.[5] As other elements with their range of potentials and characteristics appeared, different chemical reactions began to occur. With each new element a greater number of different compounds with coupled reactions became possible.

Pasteur believed that life can only spring from preexisting life, but spontaneous creation is possible and does occur. Viruses seem to be produced in such a manner as an inert chemical moiety which mutates into a living organism.[6] This similarity to living cells helps us to study and better understand life. The best known example of "reconstruction" is the tobacco mosaic virus.[7]

It should be quite clear that living material is highly variable both qualitatively and quantitatively. Obviously protoplasm is a most remarkable substance to have survived within the limits established by genetic motivations.

The more primitive the cellular matrix the greater its potential to create other cell types. Conversely, the more specialized a cell becomes, the less independently it can function or be self-sufficient. Blood cells, for instance, remain in adaptive bounds when matched with compatible groups; on the other hand, skin transplants frequently are rejected except when used in identical twins. The unfertilized sex cell is another example of the difference between primitive and more specialized material. Instead of fertilization upon contact, the host egg rejects nuclear material from a foreign genetic species, but can accept nuclear and foreign protein material of its species.

It is significant that at some point during evolution protoplasmic colloid assumed definite form. Protozoa, through adaption, was able to inhabit a specific environment. Because protoplasm varies, protozoa varies, and today there are over 15,000 known types of protozoa. The process of chromosome and gene division has remained essentially the same in protozoa from primal forms to now. Lederberg has shown that genetic recombination and the organization of genetic material in bacteria correspond to normal sexual fertilization in higher organisms.[8] This perseverance is mute evidence "that sexuality is not needed for mere survival but has adaptive advantage." Yet it is noteworthy that seemingly exact duplicates of chromosomal protoplasm do not invariably produce offspring which resemble the parents. Mendel found that genes are relatively stable; however, for some reason they do mutate and do this with mathematical regularity.

Environment and heredity always have been interrelated and impart to protoplasm the innate qualities to sustain itself. It is assumed that this characteristic could be possible only through a potential for self-initiated movement; furthermore, the organism

would perish if it moved into a noxious milieu and could survive only by finding a favorable environment. In order to sense a friendly or hostile environment the organism developed a "nervous system". This development proved so effective that it has persisted and matured to serve all living organisms.

One of the chemical processes of life is known as metabolism. During metabolism, heat and energy production is subject to the biophysiochemical law. Some of this energy is transformed into growth and this is closely related to reproduction. Reproduction indicates that life possesses the ability to spring from pre-existing life and therefore is not dependent upon some chance grouping of chemicals from the earth or churning seas. In part, however, it involves a simpler physiochemical law applicable to the decreasing ability of surface area to maintain an ever-increasing content.

There are two concepts of what occurs when a cell divides and each concept is important for a better explanation of established trends. The older concept states that mother-daughter interchange gives rise to one new cell, the mother cell somehow reverting to its fundamental abilities. The current thinking applies to the two-daughter concept which believes the original cell dies in the process of giving "birth" to two new cells and, at the instant of death, endows each progeny with phylogeny of the race.

In each hypothesis there are two major differences of opinion. One is that the daughters are exact duplicates; the other is that they are not quite exactly identical. There is some probable overlapping. For a species to persist, any change must either be nonexistent, or so minimal and so directed as to not lead to extinction, but rather retain basic similarities even though some imperceptible mutation gradually occurs through hundreds, thousands or even millions of generations as to create an entirely new species.

It is this ability to remain alike and divide equally which accounts for bilateral symmetry; it is the faculty to halve which accounts for the multicell organisms, and it is the ability of life to persist in slightly different daughters which accounts for differences in surviving species, as well as unilateral differences. Evolution and differences within the species could not be possible if identical halving occurred (unless atomic-level additions occurred). Two daughter cells are rarely, if ever, alike, and some are so markedly different that they are called mutations.

Cellular differentiation means that a specific cell has a special difference in its physiologic anatomy indicating a change in function. Many specialized cells work synergistically with others and often form colonies which act for the benefit of the total organism. This is the beginning of tissues and organs and demonstrates so clearly how natural forces are directed toward obtaining optimal maximum benefits for the organism.

For example, the body muscles of the fish show a high degree of muscle-nerve coordination. These muscles are capable of producing delicate and sensitive motions as well as powerful movement.[9] As the result of evolution, the transposition of analogous muscles to the skull of the higher species explains the delicate, integrated movements which link thoracic breathing to face and neck respiratory function. Facial expression, including articulate speech, represents advancement up the phylogenetic ladder.

About the same evolutionary period that reptiles appeared with their powerful and elongated limb enlages, the cerebral cortex also developed which was destined to become the locus of a higher central nervous system. Somatic development preceded nervous system

improvement as evidenced by locomotor and elevating muscular appendages appearing which anticipated the subsequent importance of locomotion in later vertebrates. The premammalian reptiles developed heterodontic teeth and this dental arrangement is present in man. This indicates that omnivorous man can survive on an extremely wide variety of foods and is able to subsist almost anywhere on earth.

Primates were the first vertebrates to develop prehensile hands, visceral fixation and inguinal ligaments. These structures intimated the increasing ability of primates to stand erect. The flattened chest and reduced shoulders of man resulted when brachial locomotion in the great ape diminished as he left the trees to walk erect. With uprightness, the clavicles became more horizontal as the neck lengthened. The foot of man also is a fully human characteristic.[10]

As the neuromuscular system of a human infant matures, better muscular coordination results and, because the cephalocaudal pattern prevails in man, head balance is achieved first. Next comes the ability to sit unsupported, then crawling, standing, walking, then speech sounds and the final crowning achievement of total achievement of total communication. The articulate speech mechanism of humans evidently is contingent upon an upright posture.

The brain of man, which is relatively large at birth, grows rapidly to reach almost full size by the second year. This period of rapid brain growth is accompanied by its enlarging bony housing. We have been taught that the maxilla, along with its upper dental arch, is pulled and pushed forward by its attachment with the bony cranium. Osseous cranial growth has been credited for contributing to part of maxillary growth with adjacent structures serving to coordinate and direct the forces which act to increase the amount of middle face prognathism.

However, investigations on primitive skulls which had been subjected to diverse types of cranial distortion fail to show that the maxillary teeth had been held back. Furthermore, Hellman[11] demonstrated that the face of the Australian aboriginal was farther forward than the face of the Hindu or American Caucasian skull. Craven[12] stated that "studies of the aboriginal face gave (him) the impression that the middle face completed its growth earlier than the cranial superstructure, nasion or the mandible."

These data seem to indicate that the upper face may not be dependent on brain growth as has been taught. To go a bit farther, one might even consider the possibility that vertical facial growth and reduction of the dental prognathism contributed, at least directionwise, to the forward enlargement of the brain case. This supposition gives added evidence that the energy-procuring zone of the face, and the portions of the face and cranium having to do with posture are more significant than previously recognized.

Another important consideration closely related to head-torso function is muscular physiology. Muscle tonicity in one area affects muscle tone in a related area and even in distant anatomical regions of the musculoskeletal system. Poor muscle tone, including poor posture, is frequently observed in association with malocclusion. Some of these posturotonal defects often are minimal in childhood and years later an aching back or joint pain generates enough energy to produce symptoms or discernible malocclusion which is the result of this pathology.[13]

In discussing the progression of changes attending the postural state of man, it may be logical to start by speculating on the role of the tongue. At

birth this organ has reached a greater proportion of its eventual size than any other. The tongue of the infant may appear too large for its associated parts. Actually, the tongue is not too large for the mouth because the gum pads of the infant are quite far apart and there is no limitation by the alveolar bone. As the alveolar bone matures, the early growth activity of the tongue slows down and the jaws become proportionately larger. This development is generally synchronized so that by the time the deciduous teeth begin to erupt, the jaws have grown sufficiently to easily accommodate the tongue.

Growth gradients are usually so accurate that the mandible remains in a constant relation to the other cranial structures and facial pattern. Although the maxillae ordinarily accommodate the tongue, we cannot assume that the earlier "enlarged" tongue has not caused some permanent disarrangement in the jaw — cranial — postural complex. Muscular effort exerts a certain influence within the confines of a time schedule.

The freeway space in which the tongue operates is also remarkably constant and this consistency of anatomic relationship is due to several muscle systems which are related to primary postural and functional requirements of the individual. The tongue is involved in posture and speech, as well as in sucking and breathing.

Sucking is a series of complex rhythmic motions. As the infant matures, sucking is replaced by mastication. By the time mastication becomes completely functional there is a concurrent gradual substitution by the orderly developing prehensile hands which replaces some of the functions of the mouth.

The forearms which are not required to bear weight in the human can be utilized to bring food to the mouth. This has significant implication because a snout no longer is necessary to reach down between the forepaws for food and water. Uprightness has created a different use for forelegs, except for crawling during infancy.

When food is available the hungry animal naturally attempts to seize, chew and swallow it. So that these same functions may better be accomplished in higher species, a mobile lower jaw which works against a fixed upper jaw gradually came into being. It is this movable unit which requires more discussion.

Of all the bones of the human face, the mandible is unique. Its relationship to its muscle attachments is only by the limiting factors of the temporomandibular joint and dental anatomy. Another consideration is that the so-called resting mandible really is not one of relaxation. Muscle balance with the resulting postural position of the mandible becomes both a starting and ending position of mandibular movement. Not only are the extensor muscles of the mandible involved in position or posture of the bone itself, but being the ventral antagonists of dorsal musculature, the mandibular extensors become important in body posture. It is the normal muscle tone which is responsible for determining the limits of the oral space and for support of the mandible in its position of physiologic rest between the hyoid bone and the cranium.

In higher animals the muscles of the skull are involved in posture, mastication, swallowing, as well as respiration, speech, and facial expression. Facial expression may be voluntary or involuntary and possibly cultivated by primitive man to implement speech. One may well ponder how a few sets of muscles can produce such a multitude of complicated and integrated actions. This is only possible through our highly developed central nervous system.

The most prominent landmark of the mandible of man is the forward-placed chin. Much has been written about the chin because it is one of the distinguishing features of man. DuBrul and Sicher believe that the numerous theories concerning the origin of the chin have influenced the literature more than the evolution of the chin.[14]

In lower vertebrates, especially those with protruding snouts, primates and fossil man, the alveolar portions of the jaws grow forward more than does the body portion. In contemporary European man, evolutionary processes have resulted in the reduction of lower jaw size including its teeth. This caused the front of man's mandible to swing mechanically anteriorly and dorsally as a pivot until the lowest part of the symphysis became placed more and more forward. Concurrently with this shortening of the jaw has been a change in the tongue from the long, flat organ of other primates to the present, short, highly convex one. Modifications in the mandible are only part of the process in the transformation of the total craniofacial complex. If one studies the evolution and anthropology of the species, he will observe a reduction in the alveolar length of the mandible associated with a more vertical position of the teeth.[14]

Until recently, speculation regarding this reduction of the snout with concomitant changes in the frontal plane of the mandible failed to take into account the associated trend to an upright posture. Erectness became the primary force and the prehensile hands a secondary prerequisite. Thus, as man evolved toward a more erect position, vertical height of the face increased as the cranium was brought back to a position of balance above the vertebral column. This shift also affected the base of the cranial vault, including the foramen magnum which came to lie more ventrally. The skull's articular facings gradually changed in location and direction to remain properly integrated with the rest of the skeleton. The mandibular condyles also adopted an increasing mesial facing and moved farther apart. As a result of these processes, the mandible became proportionally shorter anteroposteriorly and proportionally longer cephalocaudally. A longer neck was required for the accommodation of special muscles and voice organs. Along with this change the clavicles which are V shaped in the ape are nearly horizontal in man.

As the mandible shortened and the rami elongated, the condyles shifted just anterior to the ears, thereby encroaching upon the cushioning bursae which partition the structures in those areas. Nature provided for the forward sliding of the condyles down and over the articular eminences by utilizing a few fibers from the pre-existing pterygoid muscles to prevent compression of structures in the condylar areas. The dental pattern also changed so that the overlocking diastema arrangement present in fossil man disappeared to allow for the lateral excursions necessary for mastication and speech. These adaptive alterations, including the shrinking dental arch, do not indicate regression; on the contrary, they represent progression accompanying man's ability to stand erect and to produce human speech. The improved central nervous system with its association areas then made total communication possible. Total communication involves the storage, sorting and association of thoughts which can transmit to others the mechanisms of sounds. Speech permits intangible ideas to take form in the large association area of man's brain.

The maxilla is cranial in origin, whereas the mandible is thoracic in origin. Normally, correlation develops between these widely separated sites of growth and the condyles.

The temporomandibular articulations of man are about four inches apart in width. Because there are different environmental as well as hereditary forces, the two sides do not necessarily grow or position themselves exactly the same. However, it is very difficult to visualize or accurately measure these minute differences, either in time, space or direction regarding dentofacial relationships. Admitting there is a general tendency toward symmetry, rarely, if ever, is there an exact mirroring of the right and left sides. Rather asymmetry or functional disparity may be found.

The oral tissues and organs always maintain a general scheme of conformity in relation to the skeletomuscular system. For that matter, every human tooth fits a pattern contingent upon its function as a result of evolutionary processes. Ideally, this pattern allows for the full complement of teeth to be properly aligned. However, any alteration in growth of bone potential resulting from disease, physiologic dysfunction, or dysgenesis produces dental deviation.

Discussion

In the study of growing individuals an attempt is made to measure local growth including rate, direction and quantity. When many bones of a given species and sex are studied, the majority measure within the accepted average and are classified as normal. However, when normal ranges are compared with individual differences, it will be noted that: (1) many deceptively appearing very short or very long faces actually had facial bones within normal limits; (2) many apparently average size faces had some very long and some very short bones beyond normal limits; and (3) measurements made at different periods of maturation showed one part of the face may grow rapidly for a time in one direction, then later, a slower growing area would spurt into great activity and possibly in some other direction. This poses a question: how much deviation from average can still be considered as a normal value?

There has always been considerable speculation and argument as to the greater importance between heredity or environment, bone growth or muscular influence, and body build or disease influence. More recently, the influence of the psyche and stress has received increasing attention.[15] Philosophically this trend agrees to placing emphasis on the "total individual". Here the individual is considered to be the product of his heredity and his environment, modified by his emotional disposition. How well he adapts himself to all these factors depends upon his constitutional matrix.

Each stimulus plays some role in affecting the growth of the human dentofacial anatomy. One cannot objectively measure man unless one remembers and considers all the experience of protoplasm from the beginning of life until now. Non-erect posture, alveolar protrusion, Rh factors, and flat feet are all found in the Simians. One *cannot* completely assess man without weighing all the factors in order to reach an accurate or meaningful evaluation.

Bank of Commerce Bldg.

The author is indebted to Maurice Kaufmann, M.D. for many suggestions and editorial assistance.

BIBLIOGRAPHY

1. Tainter, Maurice L.: Our Golden Age of Medicine, *The Torch*, Vol. 31, July, 1958.
2. Beck, Wm. S.: The Riddle of Life, *Sat. Ev. Post*, May 10, 1958.
3. Hamilton, L. D.: The Hereditary Material, *Scope*, Vol. 5, No. 2, Upjohn Co., Kalamazoo.
4. Valleau, W. D.: On the Origins and Evolution of Life, *The Torch*, Oct. 1955.
5. Smyth, Henry: Atomic Energy for Military Purposes, *Princeton Univ. Press*, 1945.
6. Cook, Gordon J.: Virus in the Cell, *Dial Press*.
7. Hodge, Harold C.: Biochemistry, *J.A.D.A.*, Vol. 52, April, 1956.
8. Lederberg, J.: "Some Biological Aspects of Bacterial Genetics", Proceedings of the Second National Cancer Conference, Mar., 1952.
9. Gregory, Wm. K.: The Evolution of Dental Occlusion from Fish to Man, *Angle Ortho.*, Vol. II, July, 1941.
10. Snow, Chas. E.: Lecture notes, 1958.
11. Hellman, Milo: The Face and Occlusion of Teeth in Man, *Int. J. O.*, Vol. 13, 1927.
12. Craven, Arthur H.: A Radiographic Cephalometric Study of the Central Australian Aboriginal, *Angle Ortho.*, Vol. 28, Jan. 1958.
13. Cobey, Milton C.: Postural Back Pain, *Charles Thomas*, Springfield, 1956.
14. DuBrul, E. Lloyd and Sicher, Harry: The Adaptive Chin, *Charles Thomas*, Springfield, 1954.
15. Wolff, Harold G.: Stress and Disease, *Charles Thomas*, Springfield, 1953.

Discussion of Dr. Harold Schwartz.

In this excellent paper by Dr. Prewitt, we see Man outlined against a large background. Starting with the physics and chemistry of the cell, we see Man evolving from simple to complex forms through long spans of geologic time. This long development has left its imprint on the organism and, especially for our purposes, on his dentofacial mechanism. To do justice to the enormous complexity of this process would require many volumes. In the time allotted to him, Dr. Prewitt could only fill in the broad outlines; nevertheless, he has shown that the phylogenetic background has influenced enormously the pattern of response of the individual.

I should like to elaborate on three points. First of all, the notion that there is a teleological basis in the evolutionary process, that there is a purpose or end toward which the species is moving should be approached with caution. Such a view results from looking at the positive results of the evolutionary process while neglecting the negative results, overlooking the many blind alleys that have led nowhere, the many mistakes and apparent stumblings that have rendered countless species extinct. Modern theories attempt to explain evolution on the basis of the operation of such chance factors as environment, variation and mutation. Cosmic purpose belongs to philosophy.

The second point I wish to make is to point out the similarity between the conclusions reached by Dr. Prewitt as to the limiting effect of phylogenetic forces on the dentofacial complex, and the ideas expressed by Dr. Goldstein this morning wherein the latter states that the morphogenetic pattern places limitations on our treatment results.

Finally, Prewitt's paper emphasizes what may be called the Field concept in orthodontics. Briefly, this means that the dentofacial complex is immersed in a field of forces and agencies that act on it. Not only are there genetic and environmental forces but also, taking a broader view, the attitudes of the operator and the cooperation of the patient form part of this field. Like the action of gravitation on a planetary body in space, these forces leave their imprint on the final result. Dr. Prewitt has summed this up very well when he says:

> "Man can not measure man unless he is willing to add all the factors before the total score; then the final result is meaningful or accurate."

In Memoriam

In the passing of Dr. Donald H. Glew, Sr., we have lost a valued and esteemed colleague and friend. He was dedicated to the practice of his profession and devoted to the health and welfare of all his patients.

Dr. Glew was born in Ottumwa, Iowa, in 1900, and moved to Washington, D. C. in 1917. He received his dental education at George Washington and Georgetown Universities, receiving his D.D.S. degree in 1922 from the latter. In 1937 he entered the University of Illinois where he received graduate training in orthodontics, and on the completion of this training, he returned to Washington where he practiced his specialty until his death on April 20, 1959.

He served his profession in many ways. He was a past-president of the Washington-Baltimore Society of Orthodontists, a member of the American Association of Orthodontists as well as the Edward H. Angle Society of Orthodontia.

Dr. Glew had served in the Dental Corps Reserve at Walter Reed Hospital; during World War II, he was a member of the Selective Service Medical Advisory Board of the District of Columbia. Dr. Glew also served as a vestryman of St. Stephen and the Incarnation Episcopal Church.

Dr. Glew is survived by his wife, Pearl B. Glew, by two sons, Dr. Donald H. Glew, Jr. and Dr. William B. Glew, and a sister, Mrs. Richard Ramsell.

F.B.T.

The Angle Orthodontist

A magazine established by the co-workers of Edward H. Angle, in his memory . . .

Editor: Arthur B. Lewis.

Business Manager: Silas J. Kloehn.

Associate Editors: Allan G. Brodie, Morse R. Newcomb, Harold J. Noyes, Robert H. W. Strang, Wendell L. Wylie.

Vol. XXX, No. 1 January, 1960

The Angle Orthodontist

Instructions to Contributors

The author should submit the original typed copy of the manuscript, double-spaced on bond paper. The author's name and city of residence should appear immediately after the title, and the street address should appear at the end of the article.

Do not use symbols to indicate teeth; in *tables* teeth may be designated as U-1 or L-6, but in the text names of teeth should be fully written out.

Line drawings should be prepared in India ink on white stock; the width of lines and the size of lettering should take into account the fact that most illustrations are reduced in size in the engraving process. Photographs should be sharp, glossy prints of adequate size, *unmounted and kept separate from the text.* At the discretion of the editor, illustrations will be reproduced either as single column cuts of approximately 2¼ inches in width, or as double column cuts of 4¾ inches in width. The height of the cut may vary, but contributors should keep in mind that proportionate reduction or enlargement of illustrations affects all dimensions, and that arrangement of material should be such that awkward proportions are avoided and no loss of clarity results.

The Frankfort plane should appear in cephalometric tracings, and wherever possible should provide the basis of orientation of illustrative matter portraying the face, whether it be films, tracings or facial photographs.

Extraneous details should be eliminated from illustrative matter in order to keep the salient portions of the cut as large as possible, i.e., the cranial outline should be eliminated from cephalometric tracings unless its ommission would be detrimental to the sense of the article, photographs of patients should be cropped closely, and photographs of models should be separated by a minimal amount of empty space. Illustrations will be returned to authors for revision when they do not comply with these specifications.

Editor
Arthur B. Lewis
804 Hulman Bldg.
Dayton 2, Ohio

Business Manager
Silas J. Kloehn
Zuelke Building
Appleton, Wisconsin